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MR. ESTERBROOK, of the New York Building Bureau, continues his efforts to improve the condition of hotels in the city in regard to safety from fire, meeting, however, as might be expected, with more or less opposition from the proprietors, all of whom think that their buildings are perfectly secure already. The proprietor of the Fifth Avenue Hotel, for instance, in which, if we are not mistaken, one or two poor servant-girls were burned to death some years ago, informs a *Mail* reporter that he believes the hotels of New York to be "especially safe," and considers that "no method of exterior escape could add to the safety of his house," on account of the width of the halls and stairways and the close watch that is kept. The proprietor of the Gilsey House, a well-known iron hotel on Broadway, considers the "needless anxiety about the safety of our hotels" to be "extremely foolish;" and the owner of the Sturtevant House regards his fire-escapes as "humbugs," and thinks that while they may be of use to "a person on the lower floors of a building who is too cowardly to jump to the ground," they are useless to those who may be caught in the upper stories by a conflagration. It is no doubt true that the directors of the large New York hotels have made great exertions within the last few years to prevent accidents from fire, but there is such a thing as being too confident, and it is said that the proprietors of the Newhall House in Milwaukee, which is now denounced on all sides as a "death-trap," a "tinder-box," and so on, kept a standing advertisement in the newspapers, calling attention to their "special precautions against fire," and the "perfect safety" of their building, with, as it seemed, about as much justification as the owner of the New York storage warehouse had, whose sign "Absolutely Fireproof," displayed itself on a fragment of wall above the ruins of a structure which was completely and quickly destroyed under circumstances which should not have compromised in the least the safety of a building planned with even a moderate use of the well-known and proper precautions against fire.

IT is of some interest to architects to know that Mr. Esterbrook's directions in regard to hotels have taken the shape in many instances of peremptory orders to place balconies and fire-escape ladders or stairways on the principal fronts of the building. On the Broadway side of the Sturtevant House, for instance, three lines of fire-escapes are required, with three balconies on each floor, and on the Twenty-ninth Street side of the same building two more lines of escapes are called for. Iron stairways are to connect the balconies in the several stories, and an iron drop-ladder is to extend from each lower balcony to the street. Such additions as these to the ornamentation of elaborate hotel-fronts will be anything but welcome to their designers, and it is not unlikely that the profession may be requested to join in a remonstrance against disfigurements of the kind. If so, we hope that the request will be disregarded, in the interest of the architects of future buildings, who will gain by the trifling annoyance caused to one or two of their brethren a powerful argument to support the efforts which all of them have occasion to make in favor of a more substantial mode of construction than is now in use.

BY Act of Congress, the sum of ten thousand dollars was appropriated for the year ending June 30, 1883, to be used for the purpose of "caring for, preserving and operating the United States Testing Machine at the Watertown arsenal," and in furtherance of this purpose the Chief of Ordnance, General Benét, has arranged for making a certain number of tests of materials at the public expense. As the appropriation is small, the bill making it specifies that the Chief of Ordnance may confer with the American Society of Civil Engineers in regard to the preparation of a programme of the tests to be made during the present year, in order that the results, instead of containing a mass of random information, may be limited to a single class of stresses. Next year, in the same way, a second class of strains can be applied, and a comprehensive series of constants of the greatest value will thus be built up. In accordance with this permission a programme was drawn up and accepted, by which the official investigation for the present year is limited to the compression members of structures, and a general invitation is given to railroad companies, bridge engineers, architects, and other persons interested in the use of structural material strained in compression to cöoperate in making the tests. The Ordnance Department offers, if a test is desired of members from buildings in process of construction, or special shapes rolled for such purposes, to pay the freight to Watertown on specimens submitted, test them properly, return the fragments, and furnish the shipper with an early special report of results, giving him also an opportunity of sending duplicate pieces for a second test, if he has reason to believe that the specimens first tried were defective. Besides this, a copy of the account of all tests and results is to be furnished to the American Society of Civil Engineers, for publication and distribution.

EVERY one does not realize the immense importance of these tests to every department of the arts of construction. Already, within the three years that the Emery machine has been in use, it has effected a wonderful change in the rules for strength of materials lately regarded as infallible, and it is destined to have a still greater influence as its powers are applied to the trial of different materials. To take a single instance of what it has already accomplished, it is only necessary to mention the tests of wooden posts recently made by Professor Lanza, of the Massachusetts Institute of Technology, which have proved that the formulæ of Hodgkinson in regard to columns more than twelve diameters long, deduced from tests of small models, are quite inapplicable to timbers of the sizes actually used in buildings, and that new formulæ, based on very different principles, must henceforth be employed in this important detail of practice. Another example, which indicates still more strongly the unreliable character of the constants now universally used in architectural and engineering practice, is to be found in the trial of a number of large steel bolts, every one of which broke under a tensile strain of less than forty thousand pounds per square inch, while fragments, broken from the same bolts, showed under many tests in small machines a tensile strength in no case so low as ninety thousand pounds per square inch, while most of the trials gave a resistance of one hundred and ten to one hundred and twenty thousand pounds. The ordinary formulæ, based on tests of small pieces would certainly have given something like the latter as the constant for tensile strength, and an over-economical engineer, stretching the factor of safety to its utmost extent, might put such bolts in positions where they would surely break as soon as their load came to be placed upon them. The only thing to be regretted is that machines of equal power are not now available for testing transverse and torsional resistance, neither of which can be tried in the Watertown apparatus. That there is pressing need of such machines is shown by the result of some transverse tests of spruce timbers, conducted by Professor Lanza with an apparatus of somewhat limited capacity fitted up by himself, which gave an average modulus of rupture for beams of the sizes commonly used in practice amounting to little more than one-half that deduced from experiments with

small sticks, and presented in all text-books now in use as the proper constant. There is something rather startling in the idea that instead of four, five or six, as we supposed, the factor of safety in our structures of spruce is really but two or three; and if tests of iron and steel in large pieces should show similar results, the calculations of engineers will be still more embarrassed.

THE Western Union Telegraph Company has, although with many misgivings, undertaken to place its main wires in the city of New York underground, or at least out of reach of harm. A contract has already been made for a tube extending under Broadway from the main office of the company, near Wall Street, to Twenty-third Street, which is to contain two hundred wires. Beyond Twenty-third Street it is intended to carry the wires along the structure of the elevated railway to the northern extremity of the city, where they will be dispersed in various directions. The officers of the company acknowledge the advantage of this arrangement in point of safety from injury by weather, as well as of convenience, but fear that the grouping of wires closely in a tube will produce an unfavorable action between them, and that an accidental loss of insulation of one may make all the others useless for a time. It is much to be hoped that their anticipations may not be realized, and that the experiment may prove so successful as to lead to the adoption of similar measures by all owners of electric wires.

SOME rather unreasonable comments are being made upon the efforts of the Department of the Interior to provide for the comfort of visitors to the Yellowstone National Park. The extension of two railroads having made the Park easily accessible to tourists, the Department has been obliged to consider the question of furnishing hotel accommodation for them, a matter as important to the tourist as to the guardians of the public pleasure-ground, whose beauty must otherwise soon be ruined by the malice or carelessness of unwatched camping parties. Two expedients suggested themselves, of which one, the least promising, was to allow small hotel-keepers to erect houses of dimensions suited to their financial capacity; and the other, to make concessions of territory to persons or corporations possessing the means and disposition for maintaining, not a single small inn, but two or more, of the largest size, which could be carried on, like those of most watering-places, under a combined and extensive management. There is no question, we think, that the proprietors of great establishments are more likely to feel it for their interest to keep the natural attractions around them, on which the success of their business depends, in good order, than persons whose views would probably be less enlarged, as the amount of property which they had at stake was less; and it is equally evident that a rich corporation, even supposing its disposition to be no more favorable, would be better able than a small proprietor to keep the necessary watch, and take the proper steps for protecting anything which might need to be guarded. For this reason the Department with good reason chose the latter course, and contracts have already been made with responsible parties in accordance with that plan.

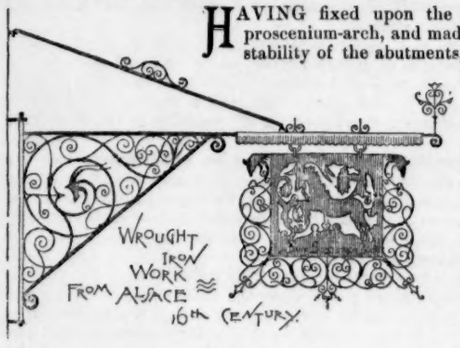
These contracts provide that in return for the concession of certain tracts of land during a limited term of years, the parties receiving them shall build and carry on a specified number of large hotels, in locations agreed upon, subject to the supervision of government officials; and it is further agreed that travellers shall be entertained in the hotels at a fixed rate of charges, which is also to be subject to the approval and revision of the officers of the Department. Together with this, the territory adjacent to the hotels is to be suitably cared for, and as a matter of course, a certain amount of farming-land is to be attached to each hotel. This arrangement, which seems to the ordinary mind admirably adapted to fulfil its purpose in the best manner, excites the indignation of the New York *Times*, which characterizes the government contractors as "a gang of speculators," and accuses them of desiring, by reason of their "private greed and extortion," to compel visitors to the Park to patronize their mammoth hotels as the necessary condition of being allowed to approach "within seeing distance" of the natural curiosities and beauties of the place. As vast tracts of the Park woodlands have already been destroyed by fires kindled by camping parties, and the volcanic geysers are nearly choked with the stones and tree-trunks thrown into them by similar careless persons, it certainly seems that a peremptory rule requiring all tourists to report themselves at the hotels, even if they choose to live in some less expensive place, might be of great value as a protection, and unless the hotel-proprietors should endeavor to force any one to become their unwilling guest, or to shut out the public from the grounds which they bear the expense of keeping in order, neither of which they are at all likely to attempt, it certainly seems as if they deserved more consideration than they now get.

A RATHER startling story has appeared in some of the daily papers, to the effect that Sir Edward Watkin, the enthusiastic promoter of the scheme for building a tunnel under the English Channel, which was so decisively checked by the British Government not long ago, has had the hardihood to disregard the repeated and stern orders of the Government, and is secretly at work in the tunnel, forcing the heading with all possible speed toward the French coast. If this is true, his operations have probably by this time carried him beyond the English boundary, but if his Government can no longer prevent him from digging under the bed of the high seas, it can at least effectually oppose the use of the English end of the tunnel, without which it will be of no use to any one. Sir Edward and his friends, if they are really at work as is said, probably believe that the Government, however strictly it may prohibit the carrying out of any given work, will hardly go so far as to destroy what has already been done, and that after the tunnel is completed, although they may be forced to leave it unused for a time, public opinion will ultimately secure for them permission to open it for traffic.

A STORY is going the rounds of the press, purporting to be derived from the statement of a friend of the late Henri Giffard, the distinguished and high-minded French inventor whose melancholy death occurred some months ago, to the effect that Giffard, who was well known as an enthusiastic aeronaut and believer in the practicability of aerial navigation, had been studying this subject for many months before his decease, and had at last discovered the means for the immediate realization of his dreams; but that further reflection upon the consequences of his discovery had shown him plainly that the inevitable result would be the destruction of civilization, and the conviction of this ended in destroying his reason. Although this story has rather an improbable sound, there is certainly room for much interesting speculation upon the probable results of a successful attempt to navigate the air, such as we have every reason to anticipate before many years. The first consideration which would occur to most persons, that of the application of air-ships to warlike purposes, is certainly an important one, for a craft of this kind, armed with a few barrels of high explosives, would be an engine of destruction far more terrible than any that has yet been conceived. Such a contrivance, impelled by the simplest means, and manned by half a dozen persons, could in a few nights reduce all the cities in Europe to heaps of ruins, without warning or possibility of defence for their inhabitants. Whether any malice less atrocious than that of an O'Donovan Rossa or a Russian nihilist would condescend to the use of such inhuman agencies, even in warfare, is doubtful, but the temptation would in some cases be strong, and if it were yielded to, the habits of the world in regard to the distribution of population would soon be profoundly modified.

A SUGGESTION for the protection of buildings in districts subject to wind-storms is found in a patent which has just been taken out for a device consisting mainly in two wire ropes, with anchors, and turn-buckles for tightening, which are to be carried over the roof of a house, and will certainly prevent it from blowing away, if the anchorage is good and the ropes strong. The principle itself is by no means new, the Summit House on Mount Washington, in New Hampshire, having been secured for many years by chains carried over the roof, and anchored to the rocks on each side, but the method may be indefinitely improved. The anchorages, if connection can be made with a proper "ground" of moist earth or water, may be used as lightning-conductors, and armed with points where they cross the ridge. Concerning the appearance of the patented device, as exhibited in a cut in the *Scientific American*, the less said the better, but it might be possible to carry the ropes or chains inside the frame, or at least under the roof-boards, so as to disguise or conceal them without lessening their effect.

BUILDING SUPERINTENDENCE. — XXVI.



HAVING fixed upon the shape of the proscenium-arch, and made sure of the stability of the abutments, we will next determine the construction of the roof, which is intimately connected with the disposition of the wall supporting it. For the sake of simplicity, we decide to make the ridge of the roof level throughout, varying only the interior construction to suit the means of support at our disposal, or other requirements.

Over the stage, where no sacrifice need be made to appearance, we will use the simplest and cheapest devices, covering the central span, of 45 feet, with a truss of the form shown in Figure 180, and the rooms at the side with plain lean-to roofs, with tie-beams, and uprights next the wall, to prevent lateral pressure upon it, and a strut to prevent the sagging of the principal rafter. This rafter will form a continuation of the rafter of main truss, so as to bring the surface of the roof in one plane. The auditorium will be covered by an ornamental roof in one span, and the upper portion of this will be continued over the gallery at the rear, the ante-rooms on each side of the gallery being covered by the gallery floor.

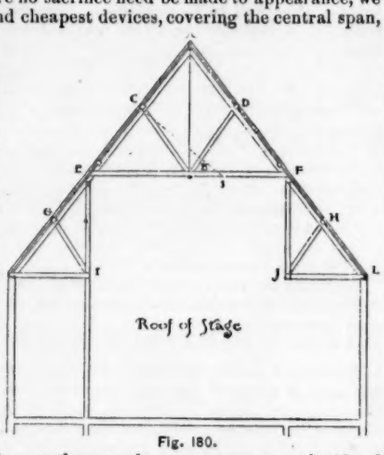


Fig. 180.

We will first investigate the simplest roofing, that over the stage. As both the large and small trusses are furnished with horizontal ties at the foot, they can have no tendency to spread, and therefore exert no thrust upon the walls; so that we shall only need to ascertain the strains upon the timbers and determine the necessary sizes. This we will do here only for the central truss, *A E F*, the principle being the same for all.

We have first to find the total weight which the roof must sustain. The length of the rafter *A E* is by the scale 30 feet, and as the trusses are spaced 12 feet apart from centres, this rafter will have to sustain $12 \times 30 = 360$ square feet of roofing, and whatever extraneous pressure there may be upon this area, such as that of snow and wind. The other rafter, *A F*, will have the same stress to bear.

It will be best to consider first the vertical stress produced by the weight of the roof, including that of snow upon it, taking afterwards the oblique stress caused by wind. The weight of the roof itself, which consists simply of trusses, purlins, common rafters, boarding and slate, without plastering beneath it, may be taken at 15 pounds to the square foot. If the roof were flat, or nearly so, a load of wet snow might occasionally be added to this, amounting to forty pounds per square foot as a maximum, but our roof being inclined at an angle of about 52° with the horizon, the snow falling upon it would slide off as it accumulated, and a snow load of 15 pounds to the foot may safely be taken as the greatest to which it will ever be subjected. This makes the total weight per square foot of roofing 30 pounds, and the rafter *A E* must therefore be calculated to sustain a vertical stress of $360 \times 30 = 10800$ pounds. The load on the other rafter, *A F*, will be the same, making the whole vertical pressure on the truss 21600 pounds. In Figure 181, express this weight by a vertical line from *A* to *B*, at any scale, say 1000 pounds to the inch. Find the centre, *C*, of this line. As the truss and its load are kept up by the supports on which they rest, the upward force of these supports, or, as we should say, their reaction, is just equal to the weight imposed upon them; or, in the diagram, half the roof *A F* and its load presses downward with the force *A C*, and is held up by the force *C A*, while the weight on the other half, *A E*, is *C B*, and is sustained by *B C*.

Fig. 181.

We must now make another division of the vertical line *A B*, to indicate the proportionate part of the whole weight borne by each joint in the truss. Looking first at the rafter *A F*, we see that the portion *D* must suffer twice as much strain as either *F* or *A*, because it sustains an area of roofing extending on each side to a point midway between it and the next joint, while *A* and *F* being held, one by the opposing rafter and the other by the support at the foot, each carry only the portion between them and the point half-way to *D*. Hence in the diagram, if *A C* expresses the whole weight on *A F*, *A K* will indicate the portion borne at *F*, *K I* will show that upon *D*, and *I C* that upon *A*. Then *C G* will show, in the same way, the strain at *A* upon the other rafter, *A E*; *GE* that upon *C*, and *E B* that on *E*. We have now all the data from which to determine the stresses on the other pieces of the truss, each of which plays a part in sustaining the total load. Beginning at the foot *F*, of the rafter *A F*, we find it to be the point of application of four different forces, the first being the reaction of the support on which the truss rests at that point, indicated by *C A* on the stress diagram; the second being its own portion of the weight, shown, as we have just seen, by *A K*; the third being an oblique pressure passing down the rafter, and the fourth a horizontal pull from the tie-beam. The direction and amount of each of these may be obtained from the diagram as follows: Starting from *C*, we pass upward to *A*, over the distance which represents the reaction of the support *F*, and in the direction of that reaction; then down again to *K*, over the space, and in the direction, corresponding to the share of the vertical load supported by the joint *F*; from *K* we draw a line, *K D*, parallel with the direction of the rafter *A F*, of such length that another line, drawn from its further extremity, parallel with the direction of the tie-beam *F E*, will just meet the point *C*, from which we started. The length of the line *K D*, according to the scale to which the diagram is drawn, will then give the number of pounds of longitudinal stress along the rafter from *D* to *F*, and *D C* will be the tensile strain upon the tie-beam between *F* and *B*.

To distinguish between the tensile and compressive strains we will indicate the former in the diagram by a light line, and the latter by a heavy line as shown.

In the same way we find the stresses upon the pieces around the joint *D*, in the middle of the rafter *A F*. We know already the stress upon the piece *D F*, which we found just now to be *K D* on the diagram; but as the compressive strain upon this piece, which was a downward push upon the joint *F*, is an upward push upon the joint *D*, we must now trace it in a direction reversed from that previously found, and starting from *D* on the diagram, follow it upward to *K*. From *K* we have another known force, the vertical load upon the joint *D*, which we ascertained at the beginning to be equal to *K I*, or twice as great as *A K*. Following this strain, then, downward to *I*, we have left two unknown forces, that on the upper portion of the rafter *D A*, and on the strut *D B*, both of which are applied at *D*, the joint whose equilibrium we are tracing. These are found in the same way as before, drawing *I H* parallel to *A D*, until *H D* parallel to *B D* will close on *D*. *H D* is then the compressive strain on the strut, and *I H* that on the upper portion of the rafter, and both are to be indicated by heavy lines.

The next strain to be determined is that on the king-rod *A B*. We have assumed that the vertical pressures are the same on each side of the roof, and the stress diagram will therefore be symmetrical, and *G F* will represent the stress on one upper rafter, and *H I* that on the other. At the joint *A*, these two stresses, together with the vertical load *I C* + *C G*, or *I G* and the pull of the king-rod, include all the forces applied at that point, and starting with the known stresses *H I* and *I G*, *G F*, symmetrical with *H I*, will be the strain on the upper rafter *C A*, and *F H*, drawn parallel with the king-rod, and connecting *F* and *H*, will represent the tensile strain on the king-rod.

Measuring with the scale the forces thus indicated, we shall find as follows: —

STRESSES FOR VERTICAL LOAD.

Tie	6400 lbs.	Tension.
King-Rod	6000 "	"
Lower Rafter	10300 "	Compression.
Upper Rafter	7000 "	"
Strut	3600 "	"

We have now to consider an additional series of strains, — those due to wind-pressure. Of course the wind may blow upon either side of the roof, but by calculating the stresses due to a pressure on one side, we shall have all the data required for extending it to the other.

We will suppose the wind to blow from the left in Figure 180. As the general direction of wind-movement is nearly horizontal, the maximum pressure in a direction normal to the plane of the rafters occasioned by it increases as the pitch of any given roof rises, and in a certain ratio to the angle which the rafters make with the horizon. The angle of the present roof being 52° it will be safe to assume a maximum wind-pressure in a direction normal to that inclination of 44 pounds to the square foot, which will give as the wind-pressure supported by the rafter *A E* in Figure 180, which is 30 feet long and spaced 12 feet from the next rafter, $30 \times 12 \times 44 = 15840$ pounds. This, as the wind will only blow on one side at a time wil

give the total wind-pressure on the whole roof, although its *direction* may be reversed. We lay this off in Figure 182 from *A* to *B*, at the same scale as in the preceding diagram, *A B* being drawn in a direction perpendicular to the inclination of the left-hand rafter.

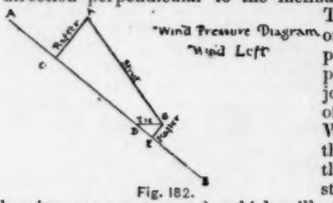


Fig. 182.

The next thing is to lay off on *A B* the points showing the proportionate portions of the pressure borne at the several joints, and also the reactions of the supports at *E* and *F*. We can easily see that, as in the case of vertical pressure, the joint *C* bears half the strain on the rafter, *A* and *E* bearing one-quarter each, which will give *A C* on the diagram as the pressure at *A*, *C E* as the pressure at *C*, and *E B* at *E*. To find the reactions of the supports we must consider that the tendency of the oblique force of the wind on the whole truss, *A E F* in Figure 180, is to turn it about the point *E*, with a leverage which will be proportional to the distance from *E* of *C*, which is the centre of the rafter, and forms the point at which the pressure, uniformly distributed over the roof-surface, may be assumed to be concentrated. We can see that the support *F* will, with this particular form of roof, be most severely strained, and the exact proportion between the loads borne by each support can be readily found by drawing from *C* a line perpendicular to the rafter *A E*, and striking the straight line connecting the points of support at 1; then measuring the distances 1 *F* and 1 *E*, which will give, *inversely*, the relative pressures borne by *F* and *E*. In this case 1 *F* is ¼ of the whole distance *E F*, and 1 *E* is ¾ of the same, from which we infer that *F* bears ¾ of the wind-pressure, and *E* only ¼. Applying this to Figure 182, we divide *A B* by the point *D*, at ¼ the distance from *B* to *A*. Then *B D* will represent the reaction of the support *E*, and *D A* that of the support *F*. Beginning with the joint *E* of Figure 180 we trace the stresses in the same way as before with vertical strains. From *E* on the diagram we pass down to *B* for the direct pressure, then upward to *D* for the reaction of the support *E*, then horizontally to *G* for the tension on the tie-beam, and down, parallel with the rafter, to *E*, the point of beginning, for the compressive strain on the rafter at its foot.

To find the strains at the joint *C*, in the middle of the rafter, we start at *C* in the diagram and pass downward to *E* for the proportion of the wind-pressure borne at *C*, then up to *G* for the reaction of the lower portion of the rafter, then upward, parallel with the direction of the strut, to *F*, until a line drawn downward from *F*, parallel with the upper portion of the rafter, will close on *C*, the point of beginning. This will give us the stress due to wind upon each portion of the rafter, the strut, and the portion of the tie-beam nearest the wind, as follows, scaling them from the diagram.

STRESSES FOR WIND-PRESSURE. WIND LEFT.

Left-Hand Part of Tie	1800 lbs.	Tension.
Left Lower Rafter	900 "	Compression.
" Upper Rafter	3300 "	"
Left-Hand Strut	8300 "	"

All these stresses would be reversed by a change in the direction of the wind.

There are still other strains to be found on the other pieces of the truss, but the reader can easily finish the diagram for himself. It is enough to say that the next point to be investigated is that at *A* in Figure 180, then *D*, and then *F*, and finally, the investigation of *B* will serve to check the correctness of the others. It will be found that the strut *B D* receives no stress of any kind from wind-pressure on the opposite side; that the portion *B F* of the tie-beam suffers a *compressive* strain of about 3300 pounds; that the rafter *A F* is equally strained throughout its whole length with a compressive force of about 8000 pounds, and the king-rod *A B* is subjected to a tensile stress of 6,500 pounds.

As the tie-beam *E F* is strained by tension, to the amount of 1800 pounds, at one end, and by a compression of 3300 pounds at the other, it would seem that the net effect of the pressure would be a compressive stress equivalent to the difference between the two, or 1500 pounds. This, is, however, an unsafe inference, the two kinds of stresses acting to a certain extent separately, instead of neutralizing each other, so that the prudent method is to take the largest amount of stress of the principal kind, without deduction for the neutralizing effect of the opposing, but inferior forces. In the case of the rafters, which are all strained in the same way, but of which we find that the one away from the wind is the most strained, we will provide for resisting the greater stress, which will make us safe against the lesser one. This will give us a corrected table of wind-pressure strains, which we will place side-by-side with those due to vertical pressure, adding them together to find the sums which will give us the total stress acting *along* each piece which that piece must be calculated to bear safely. For shortness we will mark tension as — and compression as +.

STRESSES ON TRUSS.— *Vertical Load and Wind-Pressure.*

Piece.	Vertical Load. lbs.	Wind-Pressure. lbs.	Total. lbs.
Tie, E F, (Fig. 180.)	— 6,400	— 1,800	— 8,200
King-Rod, A B	— 6,000	— 6,500	—12,500
Each Lower Rafter, C E, D F	+10,300	+ 8,000	+18,300
Each Upper Rafter, A C, A D	+ 7,000	+ 8,000	+15,000
Each Strut, B C, B D	+ 3,600	+ 8,300	+11,900

We can now obtain the sizes of the timbers and rods which will safely sustain these stresses.

The tie-beam, *E F*, suffers a tensile strain of 8200 pounds. The safe tensile strength of spruce timber, which we suppose to be the material of the truss, should not, for such a roof, be taken at more than 1000 pounds to the square inch, and a timber of 8.2 square inches sectional area, or about 2″ x 4″, would give the resistance required.

There is, however, another consideration which enters into the calculation of the size of the tie-beam. Not only does it keep the feet of the rafters of the truss from spreading, but, in virtue of its horizontal position, it is also a beam, or rather a pair of beams, each having a span equal to the distance from the king-rod to the wall-plate, about 20 feet, and burdened with its own weight, which tends to break it by a transverse strain. This strain is entirely independent of the longitudinal stress along the timber, and must be provided against separately, by increasing the size of the timber, so as to give additional fibres for resisting the bending strain, which those fibres engaged in tensile resistance to the longitudinal stress cannot deal with. We will try, therefore, a 3″ x 4″ timber in place of 2″ x 4″, and see if it gives us strength to meet all the stresses, transverse as well as longitudinal. Supposing 2″ x 4″ of this to be occupied in resisting the direct tensile force, we shall have remaining a beam 1″ x 4″, 20 feet long, which must sustain the weight of the entire timber, 3″ x 4″ x 20″ which, at 45 pounds to the cubic foot, will be 75 pounds, uniformly distributed over the beam.

The simplest formula for transverse strength of rectangular beams is $\frac{b\,d^2\,C}{s\,L} = W$ in which

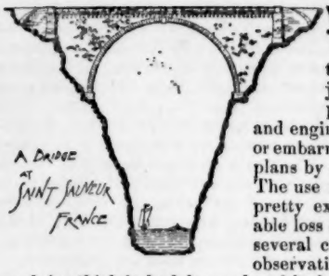
b is breadth of beam in inches.
d is depth " " " "
C is a constant, which for spruce is 450.
s is the factor of safety, which should be 6.
L is the length of the beam in feet.
W is the safe centre load.

Applying this, and remembering that the distributed load may be with safety twice as great as the centre load, we shall have $\frac{1 \times 4^2 \times 450 \times 2}{6 \times 20} = 120$ pounds safe distributed load. As the weight of the timber is only 75 pounds, we have here a surplus of transverse strength of about 60 per cent, but it is hardly worth while to make the stick any smaller. In fact, wooden tie-beams are ordinarily made of far greater dimensions than this, and with reason, for they are very liable to be used for supporting the weight of partitions either above or below, or are subjected to other extraneous transverse strains which they are less able to resist than other beams, which have no special work of their own to do, while their strength is further impaired by the mortises by which the rafters and king-rod are framed into them. The king-rod, *A B*, is of wrought-iron, and endures a simple tensile stress of 12500 pounds. The usual estimate for the safe tensile strength of wrought-iron is 10000 pounds per square inch, and as the area of a circle is .7854 of that of the square in which it is inscribed, the diameter of a round rod to hold safely 12500 pounds will be $\sqrt{\frac{12500}{10000 \times .7854}} = \sqrt{1.59} = 1.26$, or about 1¼ inches.

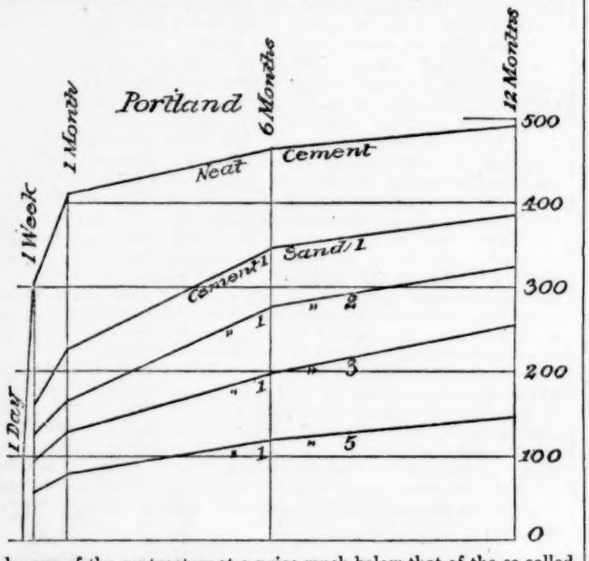
The upper and lower rafters and the struts are all subjected to compression, and their dimensions will be found by the formulas for wooden columns. Taking the lower rafters first, with a stress of 18300 pounds, we may, as they are only about 15 feet long, take the compressive strain which they will bear safely in the direction of their length at 400 pounds per square inch of sectional area. To sustain 18300 pounds will therefore be required a timber of 46 square inches sectional area, and we may use a stick 4″ x 12″, 5″ x 10″, or 6″ x 8″, as may be most convenient. As in the case of the tie-beam, a small surplus of strength must be reserved to resist the transverse strain due to the weight of the rafter itself, which tends to bend it inward, but the slight excess of these dimensions over those strictly necessary will be sufficient for the purpose. If, however, a purlin were placed, as is often the case, bearing directly on the rafter, midway between its foot and the strut, a very important transverse strain, equal to the wind-pressure on a portion of the roof 7½ feet wide and 12 feet long, together with the component normal to the direction of the rafter of the vertical pressure due to the weight of the same portion of the roof and its load of snow, amounting in all to about 6000 pounds, would have to be resisted by the rafter, acting as a beam loaded at the centre, in addition to the compressive stress acting in the direction of its length, and its dimensions would need to be increased accordingly.

The same observations apply to the upper rafter, and even to the strut, in some instances, but if we are sure that we will not forget this caution in case of need, we may, for the present, continue to study our truss as it is intended to be built, without transverse strains on any of the pieces except those due to their own weight. The upper rafter, having to sustain a compressive strain of 15000 pounds will then need, by the same rule, a sectional area of 37½ square inches, and a 4″ x 10″, 5″ x 8″ or 6″ x 7″ stick would give the required strength with a surplus for resisting the transverse strain of its own weight. The strut, which sustains 11900 pounds, may be 4″ x 8″ or 6″ x 6″. This completes the schedule of timbers for the trusses over the stage.

CEMENT TESTING.



The necessity for a careful testing of cement, before using, must be apparent to all who have given the subject much attention, and especially to those architects and engineers who have been delayed or embarrassed in the execution of their plans by an article of inferior quality. The use of poor cement is generally pretty expensive, involving considerable loss of time and waste of money. several cases having come under the observation of the writer where the work in which it had been placed had to be taken up and relaid in good cement in order to secure satisfactory results. A recent case showing the necessity for testing was the building of some large works connected with a prominent copper mine at the West, in the construction of which a local cement was used, but proved of such poor quality that when finished the work had to be broken up and English Portland used, after being subjected to tests to insure its good quality. Had the local cement been tested before using, its worthlessness would have been made apparent. The writer, who has had some eight years' experience in the testing of cements, on the construction of the Sudbury River Conduit and on the Improved Sewerage Works of Boston, has seen many curious articles offered as cement. Some two years since, a patent cement was offered the City and tested by the writer. With the sample to be tested came a circular setting forth its good qualities and containing testimonials from parties who had used it. It was subjected to the usual tests and for a time gave promise of fair results. At the end of about three months, however, the cement, which, after it had hardened in air, had been kept in water, began to swell and crack, and at the end of six months it was reduced to an inert powder, in which condition it still remains. The effect of using such a cement can readily be imagined. Another article, which came under the hands of the writer during the construction of the Water-Works was an alleged cement bought



by one of the contractors at a price much below that of the so-called standard brands, from a party who desired to place his wares in the Boston market. It was remarkably quick-setting, setting up, when mixed neat, in about two minutes, and becoming so hot as to be almost unbearable. Some seventy-five barrels of this cement were tested and not a single sample, one being taken from each barrel, was found that did not, after being moulded and allowed to harden in air, go to pieces when placed in water. It was of course rejected.

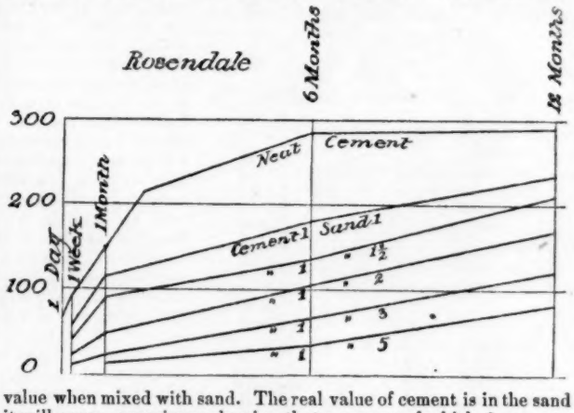
A still more recent case was that of a lot of cement offered the City and tested by the writer. Samples were taken from fifteen barrels for inspection, and subjected to the following tests to find its tensile strength, mixed neat and with sand — neat, at the end of 24 and 48 hours, and with sand (1½ to 1) at the end of 7 days — also the percentage retained by passing a given quantity through a sieve containing 2500 meshes per square inch. A briquette, mixed neat, was made from each sample, and ten briquettes were made mixed with sand, in the proportion mentioned. Each sample was mixed separately and was allowed to harden thoroughly before being placed in water. Four of the neat briquettes were taken from the water at the end of 23 hours and allowed to dry one hour before being broken, and then gave a tensile strength of only 28 pounds per square inch. At the end of 48 hours, allowing one hour for the cement to dry, the average tensile strength of ten briquettes, per square inch, was but 20 pounds. The average percentage retained by the sieve was 18, the maximum being 33 and the minimum 9 per cent. A comparison of these figures with those of the table annexed will be found instructive. Of the fifteen briquettes mixed neat, four cracked badly and one went to pieces when placed in water. Of those mixed with sand, all but three slacked, or were so weak as to break in handling at the end of seven days, the average tensile strength of the three remaining being but 10 pounds per square inch. Such a cement would be pretty costly at any price, and yet had its bad character not been shown by inspection, it would doubtless have been used to a considerable extent, only to have caused trouble and perhaps disaster.

During the time that the Improved Sewerage Works have been under construction, nearly 40,000 tests of cement have been made, principally of that which has been used in the work and for experimental purposes. This has had the effect generally of preventing poor cement being offered, the manufacturers knowing that an article not coming up to the standard adopted will be promptly rejected. In making contracts for cement for this work, it is especially stipulated that it shall be finely ground, experiments having proved that the particles retained in a 2500-mesh sieve have little or no setting qualities, and are practically of little better value than so much sand. All cements, when this residuum averages over ten per cent, are rejected.

To show the value of a finely-ground cement, one of a series of experiments made to determine this question is here given. A Portland cement was used as received from the manufacturer, which contained about 32 per cent of residuum when tested with a sieve containing 14400 meshes per square inch. This was compared with the same cement which had passed through this sieve, the coarse particles retained in the sieve being rejected. These cements were mixed with sand 1 to 2 and 1 to 3 and the results given.

	1 — 2				1 — 3			
	One Week.	One Month.	6 Months.	12 Months.	One Week.	One Month.	6 Months.	12 Months.
Common Cement, . . .	139	201	324	343	86	142	253	271
Fine " . . .	187	275	346	434	132	201	283	322

The briquettes were made at the same time and under the same conditions. The figures represent the average tensile strength per square inch of ten briquettes. Cements ground coarse, especially Portland, show a much higher tensile strength when mixed neat than when finely ground, but, as the above table shows, are of much less



value when mixed with sand. The real value of cement is in the sand it will carry, experience showing that a cement of which 9 per cent will be retained in a 2500-mesh sieve, mixed with sand in the proportion of 1 to 1½ and 1 to 2, will at the end of 7 days show a tensile strength 70 per cent higher than a mortar mixed in the same proportions, the cement of which leaves 17 per cent in the sieve. It is thus obvious that fine-ground cement is the cheapest to buy, yet the two cements from which these experiments were made were selling for the same price. A much more economical method of making cement-mortar than the system now in vogue of adding sand in fixed quantities to cement, regardless of the power to carry it, would be to proportion the amount of sand used to the fineness of the cement, a finely-ground article carrying much more and giving equally good results than a coarser cement. The result would be to use less cement and more sand, thereby making a considerable saving of expense.

Among other experiments made by the writer was one which will cause some surprise to people familiar with cements, in which it has been proved that the adulteration of Portland cement with a certain per cent of clay actually benefits the cement. The cement used was an English Portland of good quality, and the clay of ordinary quality taken from an excavation in one of the streets. Before mixing with the cement, the clay was thoroughly dried and pounded in a mortar, so that it would pass through a sieve containing 576 meshes per square inch, then added, so that three lots were made containing

respectively 10, 20 and 30 per cent in clay of the weight of the cement used in making the experiments. The table annexed gives the average tensile strength per square inch of five briquettes. Each lot was mixed with sand in the proportion of 1 to 2.

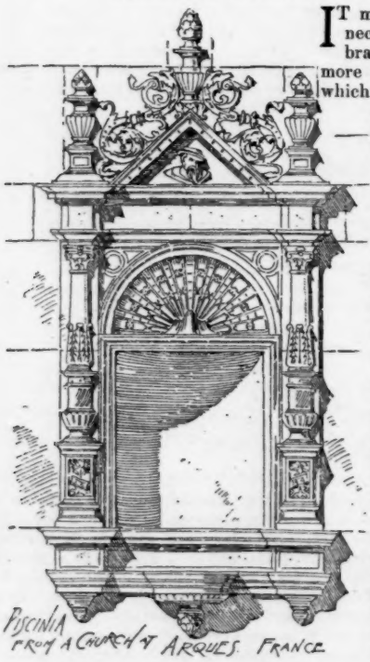
	One Week.	One Month.	6 Months.	12 Months.
Common Cement, ...	144	167	294	335
+ 10% clay, ...	185	263	345	305
+ 20% "	192	271	350	422
+ 30% "	158	238	320	384

It will be noticed that in almost every case the addition of clay has had the effect of increasing the tensile strength of the mortar.

To find a cement that will not expand after setting has been the subject of a number of experiments, the chimney test being chiefly used, but as yet, nothing has been found that has not expanded sufficiently to break or rather to crack the glass, after a few days' set. The necessity of testing cement before it is used is again urged upon those whose business it is to see that only stock of good quality is used, and who desire to have first-class work. The small expense attending it will be more than returned in the saving of time and money wasted on a poor article. The result of inspection on the construction of a certain public work has been to increase the tensile strength of Rosendale cement offered for it, from about 40 pounds per square inch in 1878 to 75 pounds in 1882. In order to secure a good article and to drive poor stuff out of the market, cement should be bought, or allowed to be used in the construction of works, only after it has passed satisfactory tests. To most contractors, a barrel of cement is a barrel of cement, regardless of its quality, and means only that article that can be bought for the least possible money, and as most of the work in which it is placed is covered, its worthlessness remains undiscovered until the cracking or settling of the work announces its presence. As "eternal vigilance is the price of liberty," so is continual testing a requisite for a good cement.

Wm. J. Condon.

BUILDERS' SCAFFOLDING. — VIII.



It may be observed in connection with the subject of bracing structures, that the more open the angle against which the *push*-force is exerted, the greater are the strains that are brought on the *struts* or *ties* which form the sides of or enclose the angle, as the rafters in a flat double-pitch roof, or a similar figure reversed; and as any variation in these angles (meaning thereby the circular extent of opening lying between the lines of direction of adjacent meeting pieces) which these pieces make with each other are of vital importance in regulating the magnitude or proportional intensities of active strains, it is desirable that their corresponding varying mechanical values, which increase in such rapid progression with the increase of the subtending angle, *i. e.* proportional to its sine, should be readily conceived and at least approximately appreciated on mere inspection by the scaffold builder, who should be cognizant of the maximum insistent loads and the intensities of their normal distribution through the various members of the structure, when in a simple geometrical form. The methods of expressing geometrically and otherwise this analogy between angles and strains, etc., we shall have to defer the discussion of for the present. All this bracing involves the elementary principle that the triangle is the only form which is fixed and unchangeable under the action of distorting forces. Among the disadvantages of imposing transverse strain on a piece, are, that it employs, in the most prejudicial manner, too, only about a half of the sectional area in either tension or compression, the other half being simultaneously subjected to a contrary stress: *i. e.* the nominal half above the neutral plane, or half of the depth of a loaded rectangular beam supported at both ends is in compression, while the half below the neutral plane is in tension. The precise position of the neutral plane in a beam depends on the kind of materials, the relation which its compressive resistance bears to its tensile strength, and the degree of deflection. There is the further disadvantage attending transverse strain, that in the loaded beam or deflecting pillar, etc., all the fibres in each half-section are strained unequally, those fibres being most strained which are farthest removed from the neutral plane. In a bent beam or pillar, there is the least strain about the point or plane where the stresses change from tension to compression in consequence of the deformation. The strain on either the top or bottom assemblages of fibres may cripple or rupture them and render them useless, whilst at the neutral axis of the beam the strain will be reduced to zero, and all the intervening fibres in each half of the section between these extremes undergo varying intensities of strains, proportional to their perpendicular distance from such extremes.

As the typical triangular frame involves no transverse strains in its pieces, whether the joints or connections of the pieces together be what are termed pin or hinge joints, or are frame or stiff joints, or in the case of a frame of quadrilateral figure wherein a diagonal brace is fitted, merely butting against the resisting surfaces in contact with it, such butting surfaces should be perpendicular to each other and oblique to the axis of the piece or member which is coincident with the line of direction of the force. When the diagonal thus butts into an angle where two adjacent members of a frame are united, it is generally cut with a double bevel, so that the end will have both a vertical and horizontal butting surface in the ratio of the vertical and horizontal components of the oblique force passing through the diagonal. In such arrangement, the main joint of the quadrilateral framework receives unaided the thrusting strains which tend to separate the parts of the joint, and therefore it should be proportioned to perform this additional duty.

As we have had occasion to describe diagonal bracing in several of the scaffold structures already introduced we may here call attention in a more precise manner to a few of the principal properties which are involved in diagonal bracing.

Figure 5 was introduced to illustrate the capacity for distortion of a four-sided figure as compared with a three-sided one. The effect of a distorting external force in the direction of the arrow was indicated by the elongation of one diagonal and the shortening of the other; the normal diagonals being shown *dotted* in connection with the distorted rectangle which assumed a rhomboidal form. The proportional elongation of the one diagonal, and simultaneous contraction of the other, though indicated geometrically as having undergone distortion up to the position shown in the figure, the comparative significance may not be so apparent to some as if illustrated by arithmetical comparison. For which purpose if we suppose that the same force continue its distorting action on the figure until the two sets of two adjacent sides which contain the expanding angles that approach each other be drawn closer together until they are in superposition (a weight upon the upper side of the frame would produce such a distorting effect), so that all four sides shall be in two continuous straight lines, the one lying above the other, in this position it is evident that the contracted diagonal has been shortened the full length of itself, while, at the same time the elongated diagonal has only been lengthened by an amount equal to the excess of the length of the two sides over the length of the normal diagonal of the rectangular figure.

Assume each of the sides of the figure to be represented by unity, and as the constant ratio of the diagonal of a geometrical square to its side is 1.4142, which accordingly represents the amount of the contraction of the one diagonal, we are enabled to find the length of the diagonal of a square of any dimensions by simply multiplying the length of the side by the constant ratio 1.4142; though ordinarily 1.414 will be close enough for most purposes. Therefore, the one diagonal has been elongated by an amount equal to the following remainder:

Two sides = 2.
Less the diagonal = 1.4142
Elongation of diagonal = .5858

while the other diagonal has been shortened to zero from its normal length, which is equal to 1.4142
Deduct elongation of other diagonal .5858
Excess of contraction over extension = .8284

It thus appears that the elongation is in round numbers about a third only of the contraction, therefore the diagonal brace under the action of the compressive force is more rapidly strained, in the absence of initial tension[1], than the other diagonal under the action of tensile strain. It is also evident that the internal force of initial tension which will assist the external distorting force diminishes rapidly under the action of initial strain. This anomaly indicates the necessity for intelligent discrimination in order to insure the judicious application of initial strain in the classes of counter-bracing where it is proper to introduce it, and hence, when distortion commences, this disparity of internal distorting forces, above demonstrated, is initiated, and continues increasing with the expansion of the one pair of opposite angles from 90° to 180°, while the sides move radially through a quarter of a circle, and the corresponding

[1] Initial tension may be briefly defined as the tightening of tie-rod counter-bracing, etc., in certain panels of trussed structural combinations, such as roof-trusses, and bridge-trusses, with the intention of anticipating the initial deformation of the truss.

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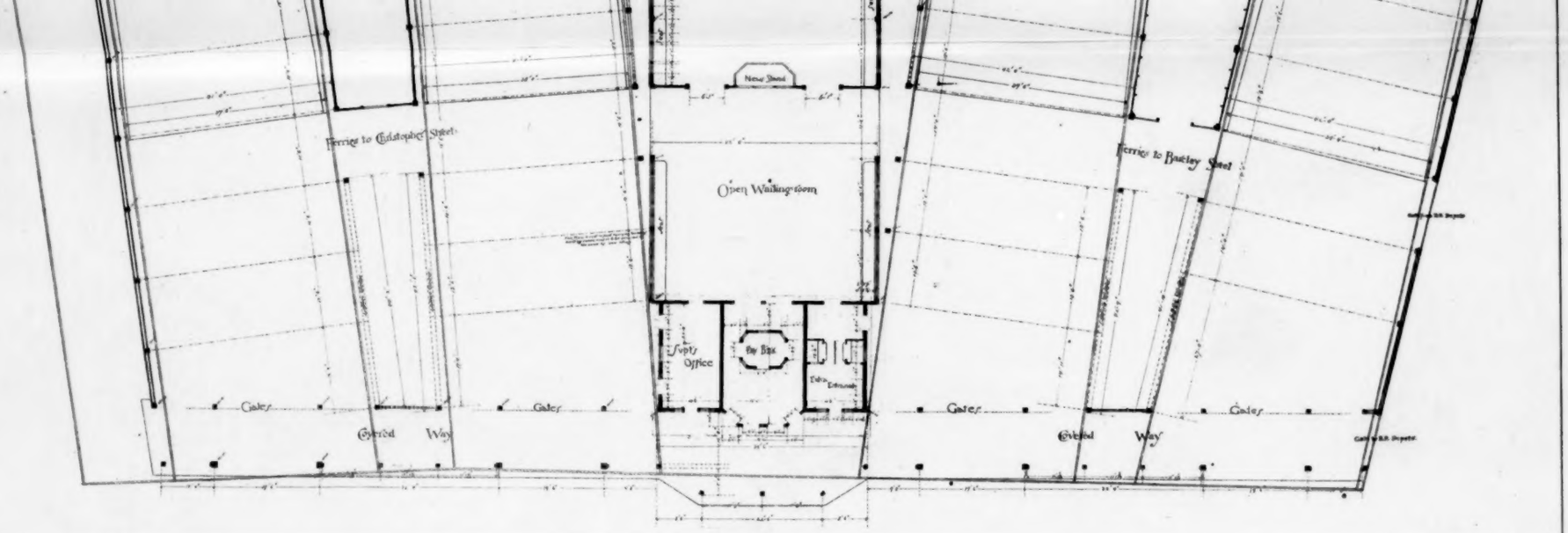
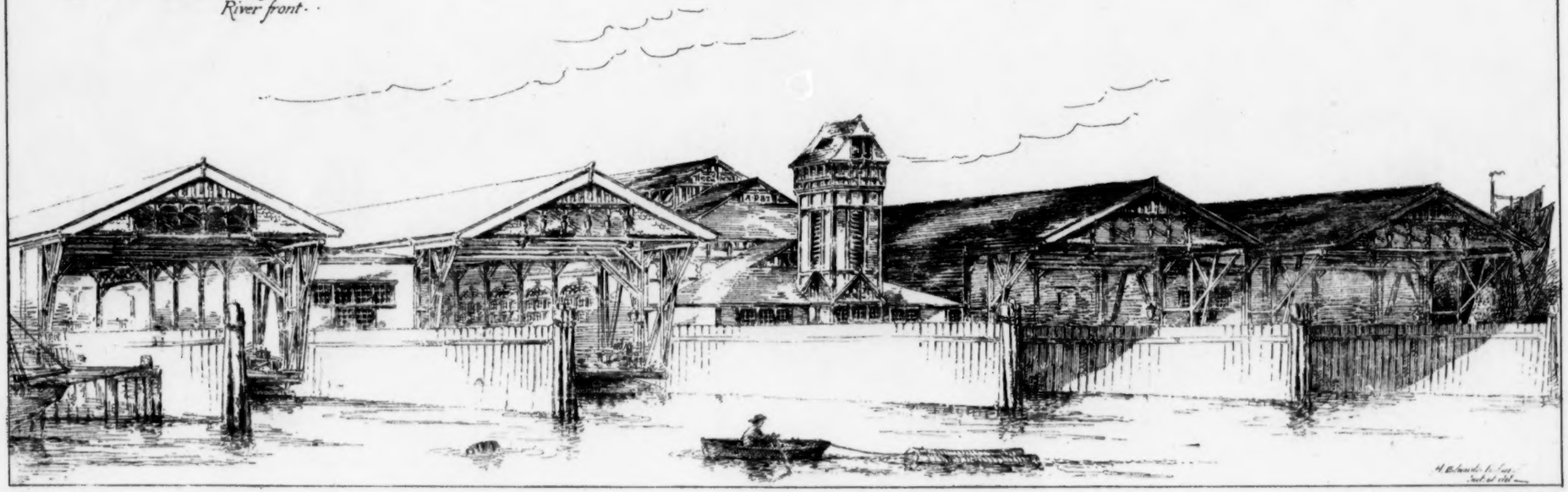
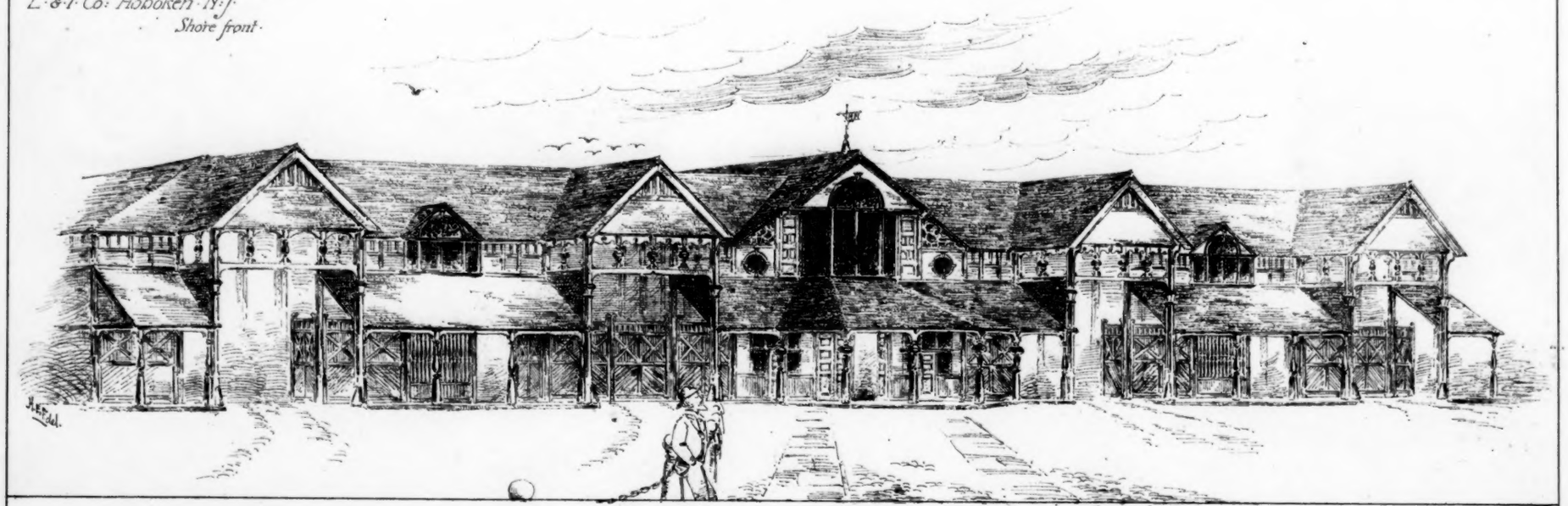


Ferry Houses of the Hoboken
L. & I. Co. Hoboken. N. J.
River front.



Heliotype Printing Co. 211 Tremont St. Boston

Ferry-Houses of the Hoboken
L. & I. Co: Hoboken N.J.
Shore front.

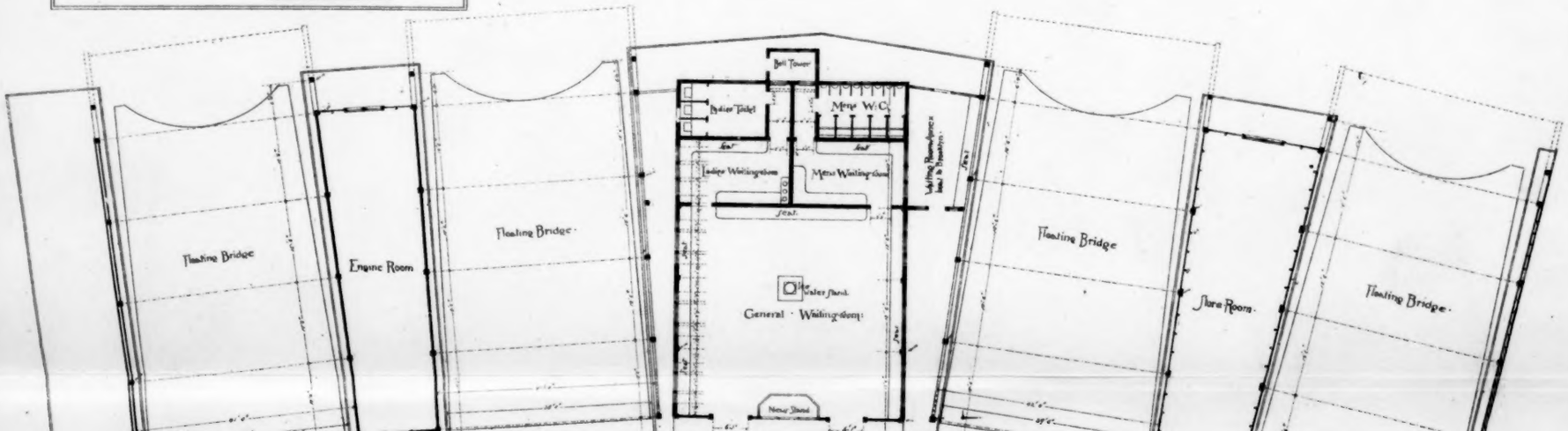


Plan of Ferry Buildings
for Hoboken Land & Improvement Co:

H. EDWARDS-FICKEN,
ARCHITECT,
19 West 22d St., N. Y.

Double lines show cutting of decks
to relieve building from shock of landing of boats.
Dotted lines show centre of trusses

North River.



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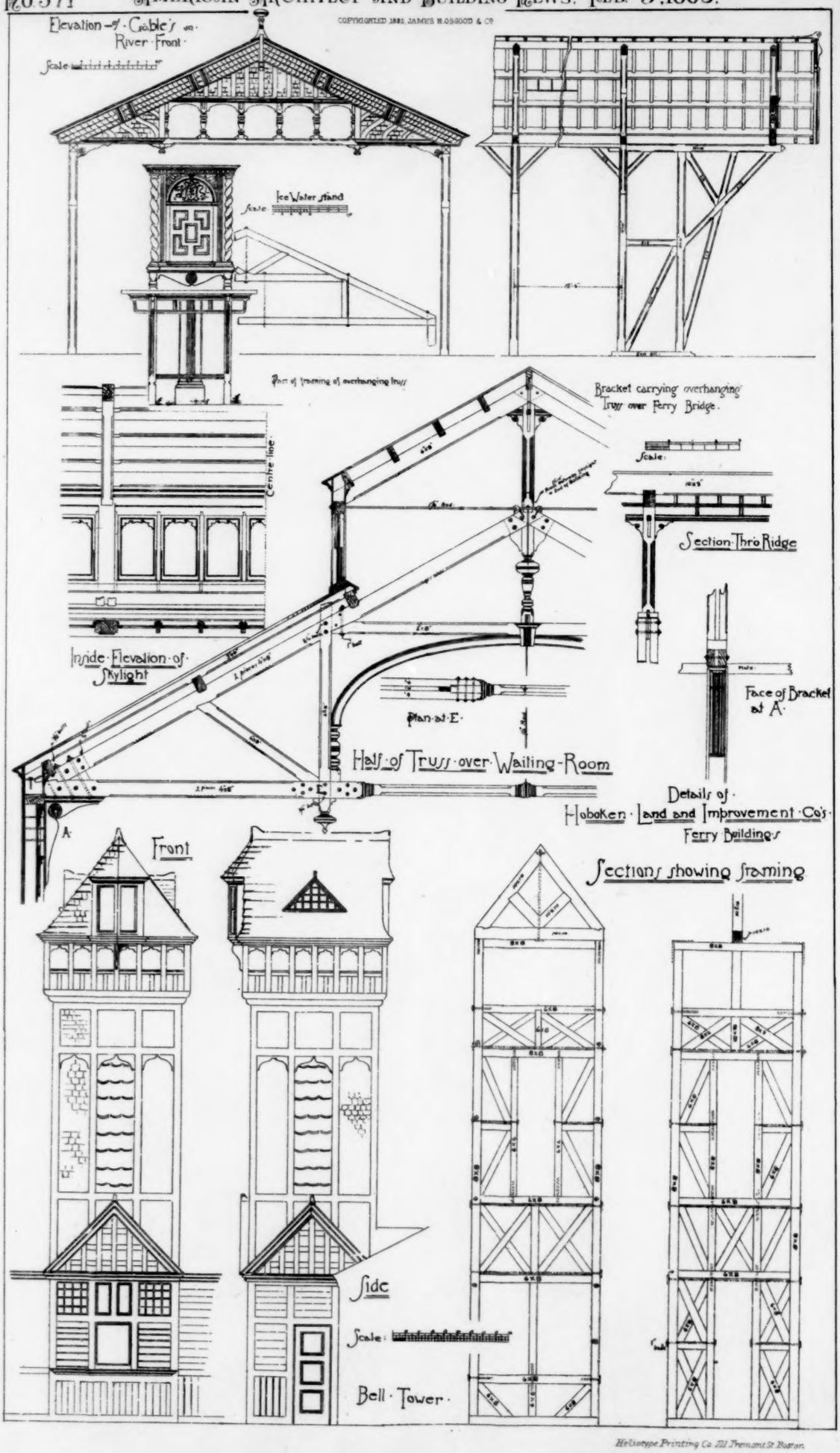

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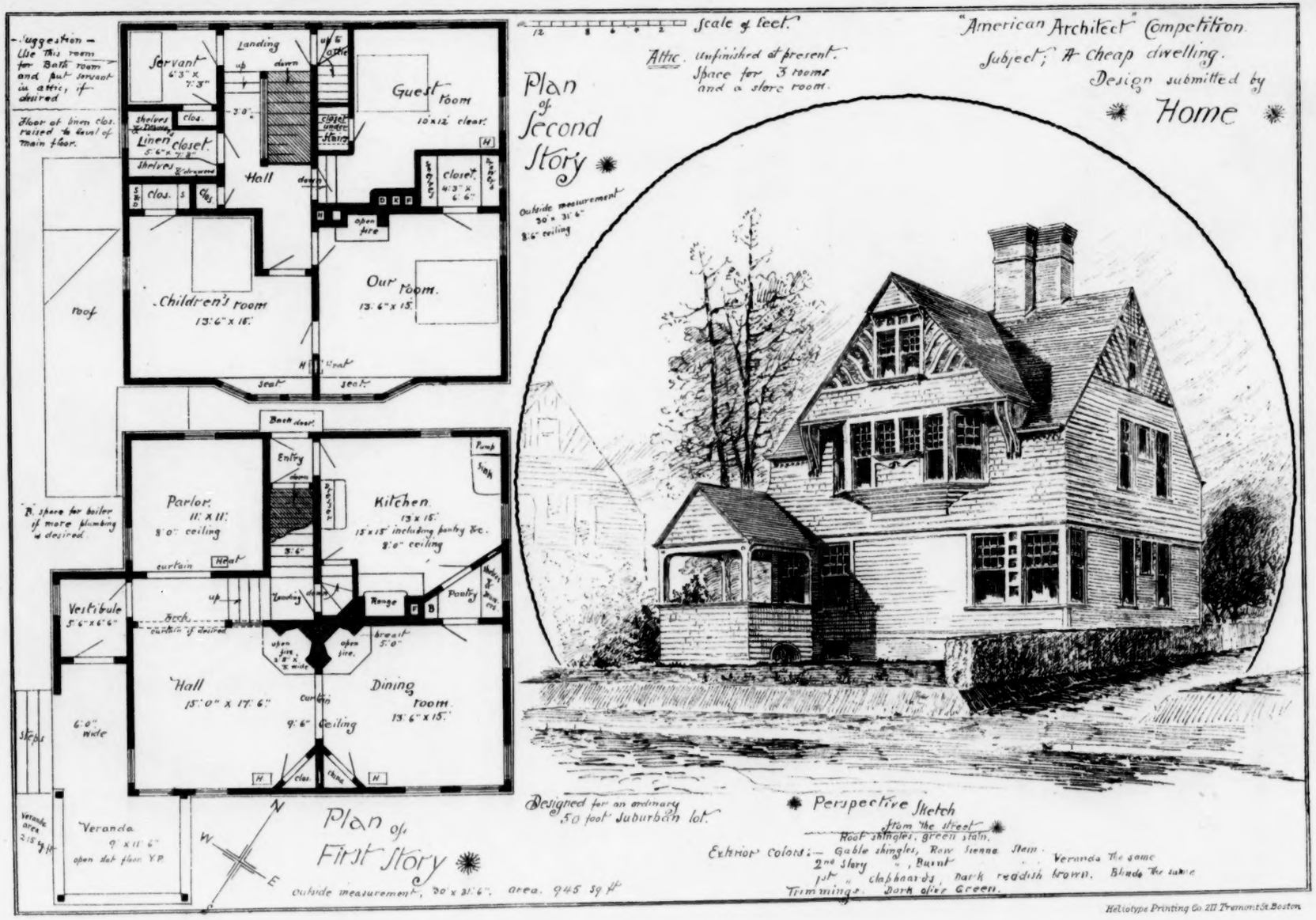

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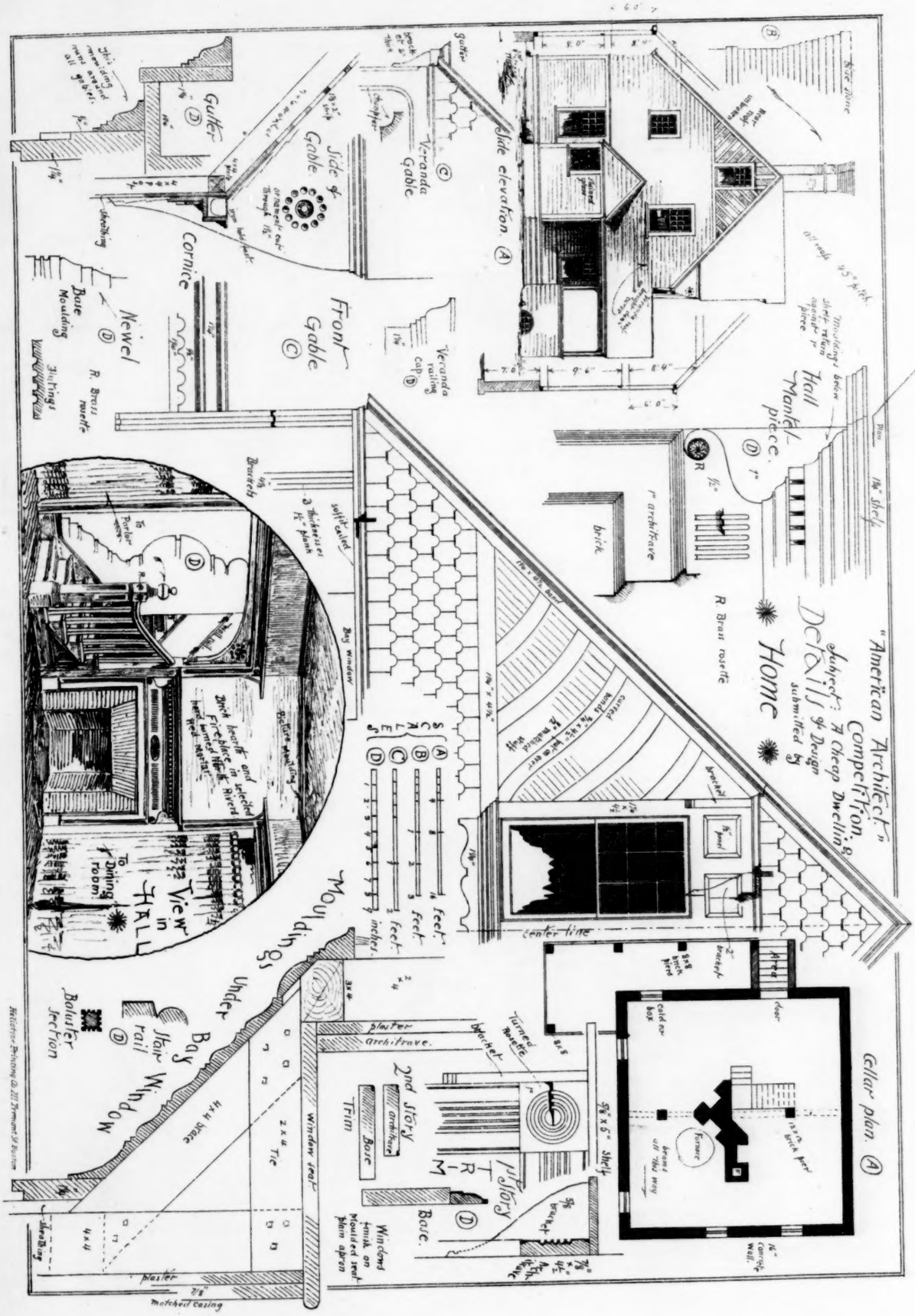

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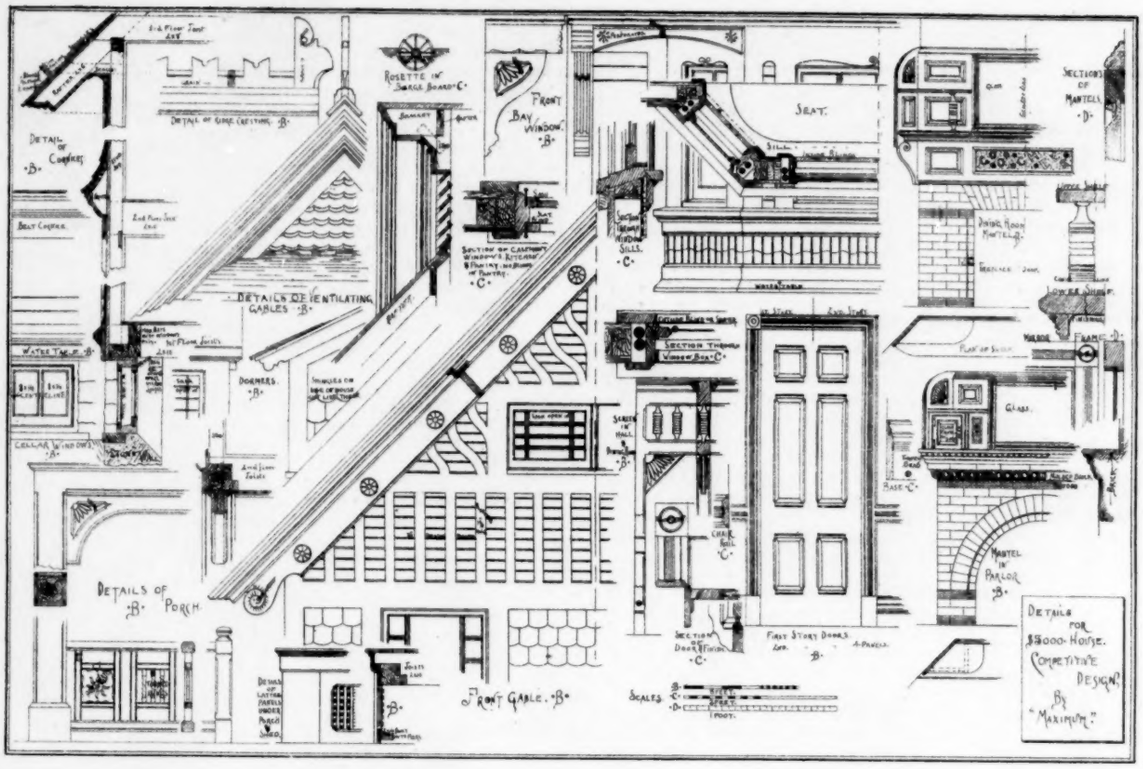

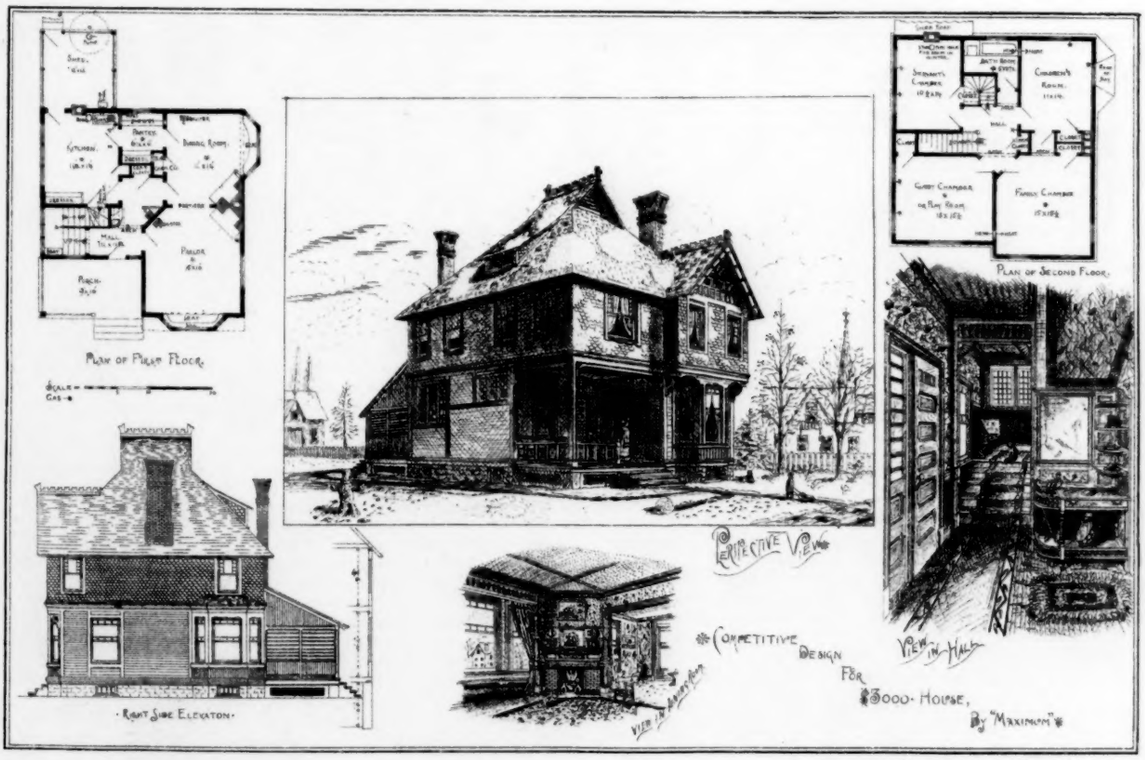

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contraction of the other pair of opposite angles, from 90° to 0°. Thus each of the pairs of opposite angles has passed through 90° or a quadrant. This will readily be seen by drawing a vertical line on the diagram from the upper vertices, where the sides of the quadrilateral figure meet the horizontal top line.

Bracing is also used in the sense of indicating the oblique piece which holds in position a vertical or inclined piece or part of a structure, by one end being fastened to it at any convenient point in its height, while the other end is fastened to a horizontal part of the structure, or other convenient object. In such a position it would form the third member in the triangular assemblage limited by its intersections with the other pieces or objects. It is therefore sufficiently evident that bracing, whether tie or strut, to be effective must be so carefully fitted and adjusted tightly as to instantly prevent, or as it were to anticipate the initial distorting movement, and hence the importance of tight-fitting, strong joints and other connections, which shall not yield at all when the maximum force is exerted against them; and under this idea what is called initial tension, as previously defined, is applied to counter-bracing of trusses, etc.; but its abuse has been a frequent source of danger to those structures by careless adjustment of tension diagonal bracings which impose excessive, uncertain and unequal strains upon the diagonals of a panel, which produces a greatly and often inordinately increased addition to the maximum calculated loads, and especially in giving a camber to trusses, — because there is no certain ready way of measuring the strains by any comparable unit of straining force, the stroke of a hammer, iron bar, etc., usually being the only means employed to indicate the state of tension; and even this test is often applied in an indifferent manner by careless workmen, having a very vague idea of the degree of intensity they impose and none whatever of the amount of stress which the sound may indicate in measurable unit force; and the same may be said of any other visible indication, as vibration, etc., or of the limit of elasticity of rods and bars, etc., or their connection swith the main parts of the structure. Any abnormal condition of strain in a structure means the constant presence of a restrained, though no less powerful, force always ready to act with unexpected energy on the instant when the restraint is in the least relaxed, and in fact it is force in a latent form, or *potential* energy as distinguished from *kinetic* energy.

1. The strain on any piece of a frame is proportional to the degree of intensity of the straining force. 2. The strain on any piece of a frame is in direct proportion to the sine of the angle which the direction of the straining force makes with the other piece, and in an inverse proportion to the sine of the angle which the pieces make with each other, because the lengths of the sides of a triangle are proportional to the sines of the opposite angles.

In many text-books there is a stereotyped caution (usually in very general terms, without recognition of any exceptions or indicating peculiar cases) against bolting or riveting together at their intersections the cross diagonal braces of a quadrilateral frame, as thereby a transverse strain is liable to be imposed on the diagonals; but as in a parallelogram, in which either the four sides or only the opposite sides are equal and parallel, (3) every diagonal divides it into two equal triangles, (4) the two diagonals drawn in any parallelogram *bisect* each other; therefore, in any frame in the form of a parallelogram there can be transverse strain on a diagonal only when there is an unequal stress of tension or compression on either diagonal on either side of (*i. e.* above or below) the point of intersection, or unequal play of joints that are not close fitting, or a yielding of splices (if any) in the individual pieces composing the frame, or unequal yielding of splices, when there are any equally distributed on each side of the intersection, or a disconnection of either joint of the diagonals where attached to the frame; otherwise the intersection remains a fixed intermediate point on both diagonals throughout any change of form of a parallelogram. But when the frame or panel of a structure is in the form of a trapezoid having its two sides taper towards the top, for instance, the intersection of the diagonals does *not* remain a fixed point in either diagonal when the frame undergoes any deformation, the portions of the diagonals above the intersection being shorter than those below: the relative lengths of these portions do not remain the same; the upper part of one diagonal is contracting while at the same time the other is extending at a different rate; and likewise in the portions of the diagonals below their intersection, the extension and contraction take place respectively in the same diagonal as in the upper portion, and also at a different rate to each other and to those of their upper portions; and hence in a frame panel of a trapezoidal form transverse strains must occur in the cross diagonals when bolted and riveted together at their intersection. As the geometrical figure in which the panels of scaffolding is usually constructed seldom assumes a true parallelogram, the caution would here seem necessary; but on the other hand any likely deformation within the elastic limit of the materials employed would not cause any crippling transverse strain. Therefore the source of danger is reduced to those of faulty workmanship in splices, joints, or other connections of pieces or members, or of the parts together of the individual members of the structure. Practically it may be presumed that any degree of deformation of a panel short of actual collapse of a structure, likely to be experienced, will not involve any amount of transverse strain on the diagonals which will be likely to produce deflection within the elastic limit of the timber employed, or such as would impair its compressive resistance, or snap the bolting or otherwise destroy the connection of the intersections, as the transverse elastic action in one diagonal would readily yield to any eccentric displacement of the intersecting point due to elastic tension or compression in the other diagonal.

In important permanent structures slovenly construction is not likely to enter, though there have been instances where imperfect bracing joints have been the cause of collapse, but in temporary structures such slovenly construction is liable to be the rule instead of the exception.

In structures which require to be carefully designed it is frequently important to observe that the bracing may be rendered not only ineffectual but vicious, by the introduction of what are called "redundant" members in the construction of frame assemblages, which may be thus explained. Frames should be constructed so as to prevent the elongation or contraction of one member producing the elongation or contraction of any other member. Thus if we draw the diagram of a frame in the form of a trapezoid, to consist of four members (with a diagonal), in which to enable us to distinguish the several members without the aid of an engraved diagram, let us number them thus: the top side let us number 1, the right side 2, the bottom 3, the left side 4, and the diagonal from top of 2 to bottom of 4, call 5. All the members are to be capable of resisting tensile and compressive strains. Such a frame cannot be distorted to any other form without causing alteration in the length of one or all of its members. If, however, one or all of the members, through a variation of temperature, if the structure be of metal, or from any other cause, shall change their length, such change will not produce a stress on any member, but will merely cause a variation in the *form* of the frame itself, and hence such a frame cannot be *self-strained*, *i. e.*, it cannot produce a stress on one member by some other member being of a wrong length, hence any error of this nature will merely change the *form* of the frame. But if an additional member be introduced, as the other diagonal, crossing from top of 4 to bottom 2, which call 6, then if 5 (diagonal) be shortened, 6 (diagonal) will be strained so as to elongate it, and the four principal members will be compressed; but if the diagonals are not made of exact length they and the four principal members will be permanently strained in either tension or compression, in unknown quantities which cannot be resolved into any known component stresses; such combinations usually ought to be avoided. A frame of this class, *i. e.*, of the double diagonal strut type is said to have one redundant member. But if both the diagonals, 5 and 6, were flexible rods incapable of resisting compression, there would be no redundant member, because the tightening of one diagonal would produce no sensible stress on the other diagonal. If the diagonal be a rod there would be two of them required to prevent a quadrilateral figure from changing its form. To technically distinguish such diagonal pieces of a frame as are only capable of bearing one kind of strain it is suggested by some writers that they be called "semi-members."

A frame such as above alluded to is technically defined as a rigid structure composed of straight struts and ties only, which are called members of the frame. The frame as a combined structure may be subject *as a whole* to a bending moment, but each member of it, whether a strut or tie, in the capacity of a column, pillar, rod, rail, or brace, composing the structure, is thereby only extended or compressed so that the total stress on a given member is the same at all its sectional areas throughout its length, while the intensity of stress is uniform for all the parts of any one sectional area. This uniform intensity must result in any frame, whose members are so connected together at the joints that they present no important resistance to change in the relative angular positions of the continuous members, as if, for instance, the members were pinned together by means of one circular pin, the axis of which coincides with the axis of the piece, and the direction of the only stress which can be transmitted from pin-joint to pin-joint, and from piece to piece passing through these pin-joints, will coincide with this axis, which becomes a line of resistance; and hence in discussing the stresses produced throughout the frame by an external force, it is treated for simplicity as consisting only of single straight lines between the joints, such joints being merely the meeting or intersection of these lines. The meeting or intersecting point of these lines at the intersecting point of the axes of the adjacent pieces of a frame or combination of frames, as in the angle of a quadrilateral panel of a truss, or braced skeleton structure, is called a "panel-point." This point is used for taking the dimensions of trusses "on centres," and for making the calculations of strains, and for representing these strains geometrically upon a skeleton diagram of the truss. These joints of frames are to be considered as possessing perfect capacity of rotary motion around the axis of the pin which, as in hinged structures, forms the axial connection of the pieces to admit of the angles formed by the connected pieces freely changing in the manner of a compass-joint.

While alluding to the theory of *redundant* structures it may be noted that redundancy generally leads to economy of construction, which is often a more expensive item than that of the materials. Though the first cost of longer and heavier scantlings may not be greater than that of short ones, it would not be economical to cut them into shorter lengths merely for the purpose of *hinging* them together again for the sake of avoiding redundancy in the structure. The

labor attending the exact location, on a large structure, of the precise geometrical position of connections, and of the laying off and construction of flexible joints, will exceed the expense of less precise connections, such as the lapping and bolting together of the ends of the pieces, which, though they will be free to move, will yet not be frictionless in the degree of properly finished articulated joints, but will not offer an amount of resistance against any angular movement of the pieces liable to take place in the frame, which would be likely to produce self-straining in the structure. Hence the fewer the articulated joints, which, to act properly, must be accurately fitted together, the less the cost of the structure. Redundancy is not justifiable when its presence is not intended to lessen the number of costly joints. In fact redundancy is rather prevalent because of the difficulty attending the making of good joints of timber. It would be absurd, for instance, to hinge together two pieces which butt against each other in a straight line, where both are in compression, when they were in such a position that there would be no compensating advantage in having them in two pieces in preference to having them in a single piece, unless the two pieces, if they were in one whole length would be of such an unwieldy size as to be inconvenient to handle, and expensive to manufacture. The thrust or compression can evidently be better transmitted through one continuous straight piece than if a joint were made in the middle of it, and the strain passed through a pin or other articulate joint in the same straight line. In the latter case the thrust cannot be transmitted past the pin or articulation without concentrating the pressure more or less on special sections and on the parts composing the joint, and thereby straining its materials unduly; and to avoid this would require a very clumsy connection as well as enlarged sections. The whole-length timber would be liable to cause a certain degree of self-straining in bending the whole-length piece like a beam. But whether this self-straining will cause more or less disadvantageous action of the excess of stress than is produced by the concentration of the thrust when being transmitted through the pin, it is in many cases impossible to know with certainty. There are certain cases in which it is found necessary or convenient to expose some of the members of a frame to bending strains, thus introducing redundancy; but many of such structures could probably be arranged to avoid the uncertainty as to the intensities of the stresses without having to sacrifice the mechanical advantages of having the two contiguous pieces united so that there should be no break in the continuity of transmitting the compression, or it may be tension. For instance, a trussed girder, with one or several vertical struts, is redundant when the naked girder is one whole stiff beam; but if the girder, instead of being in one stiff beam, were cut in two halves across the middle and bolted together by a lap-joint in the middle of the span, it would thus nominally relieve the frame of redundancy, but not secure inflexibility. The theoretical objection to beams or girders being trussed is not evaded. More than one truss-rod to the same beam is likewise objectionable, on the theory that if one rod be overstrained by inequality in length, the remaining rod will not be sufficient to afford the contemplated support without making each of them of extra strength, which would be overstepping the economy that in a large structure ought to be sedulously guarded, or else the number of rods being inconveniently increased would also interfere with economy.

A simple Fink roof-truss is redundant, being simply two trussed beams, inclined, rafter-like, to each other at an angle, and tied together at their apices; but by merely omitting the two tie-braces which radiate from its apex, it is rendered non-redundant, with however the disadvantage that the *struts* in the former case are thereby converted into *ties* in the latter form, and therefore they would afford no support to the middle point of the *principal*, but in consequence of their tension, draw it down, and endanger its being bent in the middle; whereas the first arrangement supported it. If the latter arrangement is adhered to so as to avoid redundancy, and it be required to reconvert the short tie back again into a strut so as to serve its original purpose, it would be necessary to lengthen it, so as to lower its foot below those of the principal rafter, which would make an awkward arrangement of truss for roofing.

Bracing-rods, when long and pliable, and hence liable to sag, may be stiffened considerably by connecting at their intersections, which will usually be a ring or strong casting to which they are screwed. Long bracings used in framed scaffolds are mutually stiffened laterally by being connected at their intersections, which will usually compensate for any advantage of disconnection.

All bracings should be perfectly straight in form, and in the grain of the timber. Braces acting as struts must be treated as columns of the length between their *fixed* points, and assigned their proportionate sectional area, in order to be capable of resisting deflection. Timber acting as a *tie* is stronger than as a strut; but the former depends on strength of joints and connections, in which the unreliable element of faulty workmanship enters. Large washers should be used at both ends of bolts employed in combining together the parts of timber structures. There is a common tendency amongst mechanics to regard bracing as mere guess-work, acquired intuitively in a vague sort of way, by practical experience, in which natural sagacity is deemed an all-sufficient and all-wise tutor, and therefore the necessity or possibility of estimating them exactly by mathematical formula is not thought of by mechanics not informed upon the subject. We shall have occasion to recur again to many of these topics farther on, in their proper order.

THE ILLUSTRATIONS.

FERRY-HOUSES, HOBOKEN, N. J. MR. H. EDWARDS FICKEN, ARCHITECT, NEW YORK, N. Y.

THIS building replaces the old houses which were liable to be flooded with every high tide, were ill ventilated, as all such buildings are apt to be, had no accommodation for smokers, and were generally inconvenient for the economical and rapid transaction of the immense business flowing through them, and is the result in its plan and construction of the most thorough investigation of all existing ferry-houses in the vicinity of New York and Brooklyn, and the experience of years of the officers of the company. This present building is now considered by them, after the trial of the past year, as a model for such structures, accommodating the large and impetuous flow of passengers directly from the Morris & Essex Railroad, through its gates from the depot adjoining, the still greater mass of people who night and morning go to and from both New York and Hoboken to home and business, and the accompanying freight and vehicular traffic; enabling the simplest management of the double service of it to Barclay and Christopher Streets, New York, without undue crowding, or detention of people in crowds; with ample waiting-rooms, smoking-rooms, and other necessary conveniences. The building is 225 feet long, with a covered way across its entire front, enlarged in the centre to a bay, giving shelter to those who may be obliged to wait a few minutes after passing outside or waiting to enter: this is inclosed with storm-doors in winter. White and yellow pine were used entirely in the construction, with redwood shingles on the outside wherever shingles were used. Roofs over main building were covered with gravel roofing. On the river-front the gables over the slips project about fifteen feet over the boats, affording complete shelter in passage to and from them. The tower serves as a bell-tower and has a powerful lantern, and acts also as a ventilator to the water-closets of both waiting-rooms, and, combined with proper and perfect plumbing, keeps them perfectly pure at all seasons. The long skylights over waiting and smoking rooms are worked by a patent apparatus from below. The interior finish of these rooms is in soft wood painted, and hard woods in their natural colors, and is designed after the manner of old country-house halls. In the centre of the general waiting-room is the large water-cooler for ice-water, made of cherry, of which a sketch is given. A novel feature of the plan is the angles at which the slips have been built, which were based upon the action at this point of the North-River tides with regard to the ferry uptown to Christopher Street, and the one down-town to Barclay Street.

COMPETITIVE DESIGNS FOR A $3,000-HOUSE SUBMITTED BY "*Home*" AND BY "*Maximum.*"

Should any of our non-professional readers desire to build according to either of these designs, we trust he wil do the author of the selected design the simple justice of putting the work into his hands. We shall always be pleased to put client and author into communication with each other.

THE $3,000-HOUSE COMPETITION — III.

SPECIFICATIONS FOR $3000-HOUSE. BY "MAXIMUM."

[These specifications are not considered sufficient to base a contract upon, but merely to indicate the amount of work and class of materials upon which the estimate has been calculated.]

EXCAVATION: — Top soil removed, cellar excavated to a depth of 3′ 10″ below curbstone level, dirt taken from cellar, graded up around house and top soil replaced. Grade line around house to be 12″ higher than top of curb. Excavate for cistern and piers under shed, outside cellar-way and pier under porch. No cellar under porch or shed.

Stone-work: — Cellar walls and piers built of good quarry-stone laid on flat bed in good lime-and-sand mortar. Cellar walls 18″ thick and tuck-pointed above ground with red cement. Pier under porch 2′ 0″ square with footing-course 3′ 0″ square; all other piers 18″ square. Retaining-wall to outside cellar-way 18″ thick. Flagstone sills to cellar windows 3″ thick. Stone piers in cellar to support girders under joists. Outside cellar-way to be under pantry window.

Brickwork: — Build ash-pits in cellar under fireplaces and start central flue for furnace. Build fireplaces of pressed-brick with moulded corners, etc., as shown, laid in brown mortar and well cleaned and oiled when finished. Soapstone hearths in niches with hole cut and iron lid. Pressed-brick hearths in front, laid in approved design in cement. Stove-pipe holes with thimbles in all rooms through which chimneys pass. Chimneys carried up to roof with common brick, above roof to be stretcher bricks laid in brown mortar and topped-out with cement. Flagstone caps 2″ thick, holes cut through for flues.

Carpenter-work: — Top of first floor to be 3 feet above grade line. First-floor joists, 2″ x 10″ bridged; second-floor joists, 2 x 10″ bridged; third-floor joists, 2″ x 8″; girders in cellar, 6″ x 8″; wall-plate, 2″ x 6,″ double; outside studding, 3″ x 4″; inside studding, 2″ x 4″; upper plate, 2″ x 4″, double; rafter, 2″ x 6″; collar braces, 2″ x 6″; shed rafters, 2″ x 4″; shed corner-posts, 4″ x 4″, cased; shed intermediate posts, 2″ x 4″, cased; shed joists, 2″ x 10″; shed sill, 6″ x 8″.

Frame: — The above timber to be all hemlock. Frame of house boarded over with 1″ rough hemlock or pine boards; first story covered with 5″ bevelled siding, 1″ lap; second story with cypress shingles, cut ends, 6″ to weather. Front gable covered with ⅞″ beaded boards, tongued and grooved, 3″ wide, with 1⅜″ pilasters over, walls under.

Porch: — Porch the same; porch ceiling beaded boards 3″ wide: floor of white pine boards, 3″ wide, joints white leaded.

Roof: — Roof of house open-boarded, and covered with 20″ cypress shingles laid 5″ to weather.

Floors: — Floors throughout house ⅞″ yellow-pine, first floor select; third-floor to be 24 feet square laid from refuse of other two.

Windows: — All windows first and second story to have 1½″ sashes; Kitchen, Pantry, and small windows in Hall to have casement-sashes, to open out. Kitchen windows to have inside blinds made same as outside blinds; 1¼″ casement-sash in third story to open in. All other windows in first and second stories to be double sliding-sash, hung with weights. Single windows in Hall and Parlor to have outside blinds or shutters, as preferred. Bay-windows in Parlor and Dining-room to have inside blinds, cut horizontally once. All windows in second story to have outside slat-blinds. Cellar windows to have hard-wood sills, 1½″ sash, hung at top to open in, with wire screens outside.

Doors: — All closet doors 1¼″ thick with plain, beaded, flush panel on inside face, outside to correspond with other doors: all other doors 1½″ thick, raised panels, chamfered stiles, moulded rails; first story, 6 panels; second story, 4 panels; finish as per detail. Chair-rail in Hall, Dining-room and Kitchen.

Finish: — Hall, Parlor and Dining-room finished in cypress; Kitchen, Pantry and Bath-room, yellow-pine; all other rooms in second story, white-pine; third story not finished at all. Bath-room wainscoted 4 feet high. Front door to have 5 horizontal panels, glass at top, and side-light.

Dresser in Pantry with upper and lower doors and drawers. Slide between dresser and China-closet in Dining-room. Kitchen dresser to have upper and lower doors, row of drawers at one end, and place for flour-barrel in centre, with door and lid.

Shed: — Shed wainscoted 3 feet high, upper part of slats 6″ wide pivoted on hard-wood dowels. Gables of planed boards 6″ wide battened. Rafter ends sawed same as dormers: two outside rafters planed. Roof rough boards and shingled. Cistern, 6′ x 6′, round, 1½″ pine staves.

Painting: — Outside of house to have three coats of lead and oil in three approved colors. Roof to have two coats of light red paint. Parlor, Dining-room and Hall to be finished with two coats of white shellac rubbed smooth, mantels the same. Kitchen, Pantry and Bath-room to have two coats of hard oil-finish rubbed down; Chambers and Hall, second story, to have three coats of paint in two approved colors. Floors throughout first story, oiled one coat.

Glazing: — Glass in Parlor, Dining-room, Hall, and two front Chambers, lower sash double-thick select French (not plate); upper sash, double-thick select American. Plain French-plate mirrors in Mantels. Glass in Kitchen Pantry and third-story windows single-thick American. Glass in windows on Hall landing, Cathedral tinted, worth 30 cents per square foot; border around side-light the same; centre of side-light frosted. Crackle glass in top of front door, tinted; all other windows throughout ordinary double-thick American.

Plastering: — Walls and ceilings throughout first and second stories to have two coats of brown and one coat of hard white finish. Plaster arches with quarter-round corners where shown by dotted line on plan.

Plumbing: — 14-oz. copper bath-tub, and first-class pan or Watson's closet, in Bath-room; 4″ cast-iron soil-pipe run through roof. Cast-iron sink in Kitchen with hot and cold water faucets connected with galvanized-iron circulating boiler. Slop-sink in shed with bell-trap, and hot and cold water cocks over. Cast-iron lift-pump in cistern, 6″ terra-cotta vitrified drain-pipe from street to soil-pipe, 4″ extension to slop-sink and cistern overflow. Self-acting hopper-closet in cellar for servants, and drainage-trap for cellar. The service-pipe from street and throughout house to be ⅝″ lead.

Gas-fitting: — Gas-pipes run from cellar to points on plans designated by a *.

Heating: — 36-inch galvanized-iron portable furnace placed directly under Parlor and Hall registers. One pipe to two front Chambers, one pipe to Bath-room and Children's room, and one pipe to Dining-room. Servant's Chamber to be heated in winter by stove-pipe from range passing through drum (not included in contract). Black japanned registers throughout.

Tin-work: — Best charcoal tin (IX) stock. Valley gutters 14″ wide. All water carried to rear and down to cistern through one 5″ conductor. Tin flashing to chimneys and dormers 5½″ x 4″.

Hardware: — Three-tumbler R. & E. lock to front door with real bronze front and striker, night-latch attachment with two nickel-plated keys, and fast-and-loose knob-attachment. Real bronze knobs and escutcheon plate, plate and rose in one piece. Kitchen closet to have mortice-latch, all other doors throughout house to have 4″ M. W. & Co. mortice-locks, brass fronts and strikers, and nickel-plated keys. Doors opening from Hall, Parlor and Dining-room to have real bronze knobs and escutcheons; all other doors, hemacite knobs with bronze roses and escutcheons. All doors, first story, hung with 3½″ x 3½″ copper-bronzed, polished butts, steeple tips. Second-story doors hung with japanned-iron butts, plated tips.

All double-hung windows to have Morris's sash-locks, Berlin bronze, and lifts the same; windows hung with Silver Lake white cotton braided sash-cord. All the outside blinds and shutters hung with Lull & Porter's shutter-hinges and fastenings. The inside blinds to bay-windows, Kitchen blinds and dresser-doors, all hung with 2″ polished copper-bronzed butts. Berlin-bronze spring cupboard-catches on dresser-doors and kitchen blinds. Berlin-bronze drawer-pulls to dressers; 1¼″ copper-bronzed polished back-flaps, and real bronze shutter-bars and knobs on inside shutters to bay-windows. Barrel-bolts on shed and cellar doors, the latter hung with heavy T-hinges. Real bronze bell-pull and plate to front door connected with swinging bell in kitchen:

Final: — All of the above-mentioned materials are considered to be the best of their respective kinds, and of as high a grade as the amount to be expended will allow, and are to be placed in position in the most thorough and workmanlike manner.

ESTIMATE OF QUANTITIES AND PRICES RULING AT PHILADELPHIA, PA.

Excavation and grading, 133 cub. yds., @ 40c	$53.20
STONE-WORK.	
64 perches of stone laid, @ $4.00	256.00
5 cellar window-sills, @ $1.00 each	5.00
TIMBERS AND BOARDS.	
Girders in cellar, 6 x 8 = 340 sq. ft.	
1st and 2nd floor joists, 2 x 10 = 2,450 sq. ft.	
3d-floor joists, 2 x 8 = 1,100 sq. ft.	
Outside studding, 3 x 4 = 2,600 sq. ft.	
Inside studding, 2 x 4 = 1,000 sq. ft.	
Rafters, collar-beams, etc., 2 x 6 = 1,400 sq. ft.	
Rough 1″ lumber 5,000 sq. ft.	
(@ $14.00 per M.) 13,890 sq. ft.	194.46
3,500 sq. ft. flooring measure of flooring @ $30.00 per M..	105.00
1,000 sq. ft. 5″ siding @ $30.00 per M	30.00
8,000 20″ cypress shingles @ $9.00	72.00
500 " " " cut ends @ $12.00	60.00
Plastering, 850 sq. yds. @ 25c per yard	212.50
Tin-work	25.00
Heating. Estimate from reliable dealer	90.00
	$1,103.16
BRICKWORK.	
2,400 stretchers, @ $10.00 per M.	$24.00
1,100 common, @ $8.00 per M	8.80
400 pressed brick, @ $25.00	10.00
75 moulded brick, @ $50.00	3.75
2 flagstone chimney-caps	4.00
2 soapstone niches	3.00
4 bbls. lime, @ $1.25	5.00
4 loads of sand	4.00
½ bbl. cement	.70
270 lbs. coloring matter, @ 3c.	7.10
Bricklayer, 7 days @ $3.50	24.50
Laborer, 7 days @ $2.00	14.00
Cartage	2.00
Profit	10.00
Total for brickwork	$120.85
Plumbing and gas-fitting	$240.00
Painting and glazing	$250.00
MILL-WORK.	
5 cellar window frames and sash @ $3.00	$ 15.00
13 double-hung windows, with outside blinds, or shutters, and inside finish complete, average $8.00 each	104.00
2 bay-windows, with inside blinds, inside finish, etc., all complete	50.00
Front door, frame and side-light complete	15.00
7 casement windows complete @ $3.00	21.00
Sash, frames and moulding, etc., for dormers	12.00
1 gable window	3.00
170 lin. ft. main cornice, barge-boards, etc., @ 10c	17.00
120 lin. ft. belt cornice, @ 6c	7.20
750 sq. ft. beaded boards for gable, porch ceiling and walls, @ 3c	22.50
1,000 sq. ft. dressed pine boards, for shelving, miscellaneous, etc.	25.00
Porch railing, arches, etc.	15.00
Hall and dining-room screens	15.00
13 double-face doors, average $3.00	39.00
10 single-face doors, average $2.	20.00
23 door-frames, @ 75c	17.25
684 lin. ft. inside finish, @ 3c.	20.52
2 cypress mantels, each $30.00.	60.00
150 lin. ft. of chair-rail, @ 3c	4.50
1,100 lin. ft. 9″ moulded base, @ 7c	35.00
Kitchen dresser	15.00
Pantry "	10.00
Lattice panels under porch and shed	12.00
Cresting	5.00
500 sq. ft. yel. pine 2″ plank, cellar outside and inside steps, etc.	10.00
Sum total for mill-work	$569.97
HARDWARE.	
1 front-door lock	$ 4.50
1 bronze plate and knobs for front door	3.00
1 bronze bell-pull and plate, 3½″ x 6″	1.35
22 mortice-locks, 4″, @ $8.88 per doz.	16.28
1 mortice-latch for kitchen closet	.60
13 pr. 3½ x 3½ polished copper-bronzed butts, @ $3.35 per doz.	8.45
12 pr. 3½ x 3½ japanned-iron butts	3.35
5 pr. bronze knobs and escutcheons, @ $1.40	7.00
18 pr. hemacite knobs, bronze roses and escutch'ns, @ 80c.	14.40
Swinging bell and wire, mounted	1.00
580 lbs. of window-weights, @ 1½c	8.90
6 hanks of sash-cord, @ $1.10	6.60
3 doz. pr. copper bd. 2″ butts, @ 75c per doz.	2.25
19 Berlin bronzed sash-locks, @ $3.00 per doz.	4.75
19 Berlin bronzed sash-lifts, @ 30c per doz.	.48
1 doz. pr. back-flaps, copper bd.	.70
1 doz. real bronze shutter-bars,	2.65
3 " " " knobs, @ $1,	3.00
14 pr. 3″ cast-iron butts, for C. windows	.70
Hooks and staples	.50
13 sets of Lull & Porter's shutter-hinges	2.30
1 doz. Berlin bd. drawer-pulls,	.60
18 cupboard catches	1.50
6 doz. japanned wardrobe hooks, @ 15c	75
12″ T-hinges for cellar-door	.38
2 barrel bolts	.36
2 gross screws	.66
100 lbs. 10 *d* nails	3.75
200 " 8 *d* "	8.00
200 " 4 *d* "	8.50
50 " 20 *d* "	1.87
5 " 8 *d* finishing nails	2.50
Total for hardware	$121.63
Extras	20.00
Architect's fee	75.00
Carpenter-work and profit to contractor	500.00
Total estimate	$3,000.61

SUMMARY.

Hardware	$121.63
Stone-mason's contract	314.20
Lumber, shingles, etc.	461.46
Plastering	212.50
Tin-work	25.00
Heating	90.00
Brickwork	120.85
Plumbing and gas-fitting	240.00
Painting and glazing	250.00
Mill-work	569.97
Architect's fee	75.00
Carpenter-work and profit	500.00
Extras and contingencies	20.00
Total	$3,000.61

Of the above estimates, the stone-mason's, bricklayer's, plasterer's, painter's, plumber's, heating, carpenter-work, and tin-work were all furnished by reliable men in the different lines of trade. The prices of hardware were given by J. B. Shannon & Sons, 1009 Market St., Philadelphia, from goods selected from their shelves. All of the respective contractors guaranteed a first-class job in their respective lines. The estimates are intended to erect the building in the vicinity of Philadelphia, but in the western part of Pennsylvania or New York they would be about thirty per cent lower.

DESIGN SUBMITTED BY "*Home.*"

EXPLANATORY SPECIFICATIONS.

MASON-WORK: — 16″ concrete cellar wall, built between plank, and against the earth. Small stones, rammed down in cement-mortar. When finished has a coat of cement inside and outside (above ground). Jambs and corners in brick.

12″ Brick piers, and chimney foundations in brick.

Best hard-burned brick throughout.

Bluestone sills and chimney-cap. Bluestone lintel in kitchen.

Cellar bottom, concrete and cement.

Chimney topped out in selected hard-burned brick.

Open fireplaces and hearths laid in hard-burned brick.

All brickwork showing to be laid in red mortar, with sunken joint.

8″ brick around all flues, withs 4″. Cellar area, 8″ brick wall coped with bluestone.

Flagging steps, brick risers.

Cistern: — 10′ diameter. 10′ 6″ deep to spring of dome. 4″ brick wall backed up with concrete. 8″ dome. Concrete bottom, laid in and smoothly coated over with Rosendale cement. Flag over man-hole. 4″ brick filter wall. Build in 4″ tile-drains from foot of all leaders. 6″ overflow to small, dry stone cesspool.

Drain: — 5″ glazed pipe; 100 feet to cesspool; moveable cover to running-trap; 5″ vent between trap and house.

Cesspool: — 8 feet diameter, 8 feet deep to spring of dome, same as cistern, coated with cement. Two vent-pipes to grade, one longer than other; overflow to a charcoal pit.

Plastering: — Two coats on hemlock or spruce lath; finishing-coat rough sand-finish, white sand and Morris Plains, N. J., sand, mixed. No cornices or beads, arches or brackets; brick mud filling between first-story beams.

CARPENTER-WORK.

Timber and Lumber: — Hemlock frame and sheathing; exposed timber and lumber, second-quality pine, except clapboards, which are to be clear pine. Interior work in clear white-pine. Finish in pine throughout, except stairs, which are to be yellow-pine. Floors, second-quality pine.

Attic: — Attic unfinished, except that it has a floor. As the family increases, the attic can be made available.

Framing: — Balloon method. Timbers all 16″ centres. For sizes see bill of quantities. Double cross-bridge every five feet. Long braces cut in, partitions trussed, openings trussed, bearing partitions footed on partition-head.

Roofs have 1 1-8″ x 2″ strips nailed to rafters, 5″ centres on which to lay shingles; rest of frame sheathed with 1″ x 8″ hemlock put on diagonally; sheathing paper over sheathing. Beaver, No. 2; clapboards 6″ wide, 1 1-4″ lap.

Corner boards, casings, bands, etc., 1 1-4″ x 4 1-2″, rebated where necessary to receive shingles and clapboards.

Shingles: — On second-story walls, veranda, and roofs, sawed pine, irregular widths laid in usual manner in regular courses. Gable shingles sawed pine, regular widths; water-table 1 1-4 x 8″; belt course, 1 1-4″ x 4 1-2″

Veranda: — 1′ x 3″ yellow-pine floor, laid 1-8″ apart, boxed posts and plate; close railing, shingled outside, ceiled inside, railing cap; ceiling ceiled straight across.

Gables: — Single moulding and band. See detail.

Cornice: — Mouldings under projecting bay, etc. See detail.

Blinds: — Hall, Dining-room and windows in bay, to be Venetian slat-blinds. Other windows of first and second stories, 1 1-4″ rolling-slat outside blinds.

Floors: — First story has double floor with paper between. Under floor rough hemlock. Other floors 1″ x 6″ matched pine. Hard-wood saddles for doors.

Doors, regular sizes, factory-made. Furniture of the most inexpensive kind — see quantities.

Windows: — Small lights in upper sash; lower sash, single light. Double-hung in usual manner. Small windows casement-hung.

Glass: — Double-thick French sheet for lower sash; upper sash in American glass.

Trim of the simplest description. See detail.

Mantel-pieces: — Pine. Three of them to cost not over $75.

Stairs: — Cellar, plain and strong; open risers; no rail. Main flight, yellow-pine newels, rail and balusters. See detail. Boxed from landing up, with hand-rail secured to wall. Box stairs to attic; no rail.

Fittings: — Dresser with glass doors in Kitchen. Closets provided with shelves and drawers. Picture-moulding in Dining-room, Hall and Parlor.

Plumbing: — Plan is arranged so that Servant's room in second story can be made a Bath-room if it is desired to have more plumbing.

Range: — "Fawn" No. 2., Simond's Manufacturing Company.

Sink: — 20″ x 30″ *cast-iron sink*. 2″ waste to drain. Waste-pipe carried up from top of trap out of roof.

Ordinary suction-pump in Kitchen, connected with cistern.

Tinning: — Gutters lined and usual tin flashings; galvanized-iron leaders.

Painter: — Fireplaces and hearths, two coats of oil. Chimney exterior, two coats oil. All exterior wood-work to have a coat of crude petroleum oil. Shingles to be dipped in the oil. Oil stained colors desired. Shingles to have another coat of oil (linseed) with stain, making two coats of lead and oil paint. For colors see under perspective.

Veranda ceiling and floor, two coats of oil. Inside work, Second-story and Kitchen, two coats of paint. Rest of house two coats, Dexter Bros., 57 Broad street, Boston, mahogany stain, rubbed to a smooth polished surface.

Furnace: — Portable, moist air. (John Hyslop, 206 E. 29th street., New York, N. Y.)

ESTIMATES OF QUANTITIES AND PRICES RULING AT SOUTH ORANGE, N. J.

[Prices of Labor: Carpenter, $2.50 and $2.75; mason, $2.50 and $3.00; laborers, $1.75 and $2.00. This is the winter schedule, the outside prices of which are taken in this estimate.]

Contractor: — A. F. Behring, contractor, 327 Fourteenth Ave., Newark, N. J., has verified these quantities and prices. He is now building a house similar in plan, but more elaborate and broken up in exterior, for $3,375. This, however, includes plumbing to the amount of $347.

Waste: — The allowance for waste, etc., is reckoned-in in each item, varying from 5 to 10 per cent.

[Especial attention is called to the simplicity of construction: A square house — central partitions carried up; gable roof, broken only by a gable in front; no break in the rear.

The front part of the house (first story) has a 9′ 6″ ceiling; rear part, 8′. Second story, 8′ 4″ throughout. In second story, 6′ from floor to roof-line, where rooms are cut off by roof.]

MASON.

264 cub. yds. excavation @ 35c..	$82.40
Extra for grading around house,	25.00
52½ perch concrete cellar wall, including cement and labor, laid, @ $5.00	262.50
14 perch grouting and cement bottom for cellar, @ $4	56.00
15 MM. hard-burned Jersey brick @ $9.50, delivered..	142.50
Laying the same, 15 MM., @ $8, including cement, etc	120.00
712 sq. yds. plastering, @ 30c. (This includes labor and cost of materials, lime, lath 3,500, etc.)	213.60
270 ft. drain-pipe, @ 20c	$54.00
Trap for same, $1.25; vent-pipes, etc., $1.50	2.75
Range lintel	2.00
Chimney-cap	4.50
15 feet bluestone sill, @ 25c	3.75
54 feet bluestone steps, @ 25c	13.50
Patching, plastering, etc	10.00
Labor, etc., not included in above	20.00
Total mason-work	$1,612.50

HEMLOCK TIMBER AND LUMBER.

No.	Size in inches.	Lengths in feet.		
1	6 x 8	18	girders in cellar	72
3	6 x 8	10	girders in cellar and	120
1	6 x 8	16	girders in cellar and for veranda	64
40	2 x 10	16	first and second story joist	1067
11	2 x 10	24	veranda	440
8	4 x 10	16	trimmers and headers	427
16	2 x 8	16	attic joist	341
4	4 x 8	16	" trimmers and headers	171
6	4 x 6	18	main posts and braces	216
8	4 x 6	16	sill	256
5	4 x 4	24	plates	80
2	4 x 4	16	and braces, etc	43
34	3 x 4	20	window and door studs	680
3	3 x 4	14	" " "	42
8	3 x 4	16	" " "	128
10	3 x 4	18	partition-heads and braces	180
48	2 x 4	22	studs	704
25	2 x 4	24	"	400
28	2 x 4	20	"	280
12	2 x 4	18	"	144
8	1½ x 4	16	girts	53
16	2 x 6	12	ceiling-joist, veranda	192
24	2 x 6	24	rafters	576
10	2 x 6	20	"	200
34	2 x 6	16	"	544
2	3 x 8	20	valley-rafters	80
1	3 x 8	10	" " veranda	20
240	1½ x 2	16	strips for shingles	720
5000 ft. rough flooring and sheathing				5,000
				13,140
Total, say 13½ MM. hemlock, @ $18.00				243.00

Paper, 5,000 sq. ft. (uninflammable) @ ½c	25.00
Shingles, 17½ MM. sawed pine, @ $4.50	79.25
Clapboards, 1,500 sq. ft., @ 3c	45.00

SECOND-QUALITY PINE.

500 ft. matched ceiling ½", @ 3c	15.00
2,200 ft. matched flooring (first and second story.) @ 4c	99.00
1,000 ft. matched flooring (attic) @ 3c	30.00
1,000 ft. bands, W. T. belts, etc., @ 4c	40.00
750 ft. exterior door and window frames, @ 4c	30.00
200 ft. cellar area, cold-air box, etc., @ 4c	8.00

Mouldings, Trimmings, etc.

350 ft., 2 x 3½, @ $4.70	16.45
50 ft., 1¼ x 2, @ $1.35	.68
75 ft., 1 x 4, @ $2.15	1.58
25 ft., 1 x 3½, @ $1.75	.44
10 ft., 5 x 1½, @ $4.00	.40
250 ft. (first-story door-trimming), ¾ x 4½, @ $2.40	5.00
26 corner-blocks (doors), 4½ x 4½ x 1", @ $4.00	1.04
20 corner-blocks (windows), 4½ x 4½ x 1" @ $4.00	.80
150 ft. (windows), ¾ x 4½, @ $2.40	3.60
100 ft., 1 x 1, @ $.85	.85
100 ft., 1 x 1, @ $.85	.85
150 ft., ¾ x 2½, @ $1.35	2.03
175 ft., 1½ x 3 (picture moulding), @ $1.75	3.07

CLEAR PINE.

300 ft. door-jambs.
250 ft. room-base.
400 ft. second-story trimmings.
500 ft. fittings, etc.
350 ft. stairs.

Total, 1,800 ft., @ 5c	90.00
Miscellaneous sundries, 500 ft. pine, @ 5c	25.00
3 mantel-pieces complete, set up (estimate)	75.00
Stairs. Newel rail and railing, yellow-pine	20.00
Veranda flooring, 1 x 3, 200 ft., @ 4c	8.00
63 ft. rolling-slat blinds, @ 27c.	17.01
150 sq. ft. Venetian cherry slat (London back), @ 30c	45.00
3 moulded doors, 3 x 7 x 1¾, @ $3.09	9.27
3 moulded doors, 2′ 10″ x 6′ 10″ x 1¾, @ $2.92	8.76
17 moulded doors, 2′ 8″ x 6′ 8″ x 1¾, @ $2.75	47.50
Total	$2,006.98

HARDWARE.

1 Front door mortice-lock and night-latch. Polished brass knobs, etc., two keys	$4.75
5 Mortice-locks (4½") with light bronzed knobs, etc. Keys, @ $1.00	5.00
17 Mortice-locks (4½"), brown mineral knobs, etc., @ .50	
1 Padlock @ .30, and 4 strap-iron hinges @ 7c. Cellar area doors	.48
6 5" loose-joint japanned butts @ 35c	2.10
16 pr. 3" x 3" ordinary butts @ 8c	1.28
4 Flush-bolts for two outside doors	1.34
36 Drawer-pulls, imitation bronze @ 2c	.72
18 Sash-fasteners, imitation bronze, @ $1.00 per doz	1.50
13 Fastenings for casement-windows @ .20	2.60
13 pr. hinges for casement-windows @ 4c	.52
1 Lock and bolt for dresser glass doors	.70
1 Front-door bell (18 ft. to Kitchen), brass pull	1.50
36 Iron hooks @ 1c	.36
540 lbs. iron sash-weights @ 1½c.	8.80
216 ft. hempen cord @ ½c., and 72 pulleys @ 4c	3.74
540 lbs. nails @ 4½c	24.30
Total	$68.18

SASH (Glazed).

Estimate furnished by Bradley & Currier, New York.

9 Sing. sash, 2′ 6″ x 3′, 1¾ 12l. Am. gl. @ 1.30	$11.70
9 Sing. sash, 2′ 6″ x 3′, 1¾ 1l. Double-thick F. gl. @ 1.88	16.92
4 Sing. sash, 2′ 0″ x 3′ 0″, 1¾ 2l. Am. gl. @ .90	3.60
4 Sing. sash, 2′ 0″ x 2′ 6″ 1¾ 9l. Am. gl. @ 1.00	4.00
4 Sing. sash, 2′ 0″ x 2′ 6″, 1¾ 1l. Fr. gl. @ .85	7.40
6 Sing. sash, 2′ 6″ x 2′ 6″, 1¾ 12l. Am. gl. @ 1.10	6.60
4 Sing. sash, 2′ 6″ x 2′ 6″, 1¾ 1l. Fr. gl. @ .85	7.40
6 Sing. sash, 2′ 6″ 3′ 0″, 1¾ 1l. Am. gl. @ 1.50	9.00
6 Sing. sash, 2′ 0″ x 2′ 6″, 1¾ 1l. Am. gl. @ 1.40	8.40
9 Sing. sash, 2′ 0″ x 3′ 0″, 1¾ 12l. @ 1.15	10.35
2 Sing. sash doors, 2′ 0″ x 4′ 6″ 1¾, 9l. Am. gl. @ 2.15	4.30

LABOR.	
Carpenter-work not included in above	6.50
	$2814.84
TINNING.	
120 ft. flushing, @ 10c	12.00
60 feet gutter, @ 16c	9.60
70 ft. leaders, @ 20c (gal. iron).	14.00
PLUMBING.	
Range, without water-back, Simond's M'f'g Co., "Fawn"	15.00
Cast-iron sink, plain, 20" x 30'	3.00
Suction-pump	3.25
25 ft. 2" waste, @ 25c, put up	6.25
20 ft. 1¼" pipe, @ 30c, put up	5.00
Labor, etc., not included	5.00
Painting. (Estimate, C. H. Ford.)	130.00
	$3,017.94
Cartage and freight not included in above	40.00
	$3,057.94

Mr. Behring will contract for all the above, including builder's profit, etc., for $3,200. "*Home*" reckons $3,2** as an allowable approximation within the terms of the competition. If it were necessary, the price might easily be reduced to $3,100.

Architect's commission, 6%, $192.00.

One of Hyslop's moist-air furnaces, portable, with tin heat-pipes, set up, $135. These last "*Home*" considers as extras within the meaning of the competition.

MIXING COLORS.

TO THE EDITORS OF THE AMERICAN ARCHITECT:—

Gentlemen, — Can you inform me through your paper what is the best elementary work on mixing colors, both in water and oil, for a beginner, and oblige, Yours respectfully, M. E. KNIGHT.

[FIELD'S Chromatography. Any of the Winsor & Newton hand-books on painting, either in oil or water. — EDS. AMERICAN ARCHITECT.]

THE BLUE-PRINT PROCESS.

CINCINNATI, January 18, 1883.

TO THE EDITORS OF THE AMERICAN ARCHITECT:—

Dear Sirs, — Please let me know in your next issue if the blue-print process (blue on white ground), mentioned in your February number, 1882, is the same as that claimed by Albert Levy to be C. L. I's patent of October 25th, 1880, and whether he has a right to this claim. If not, please let me know whether the above-named process is patented in the United States or not. Yours truly,

A SUBSCRIBER.

[WE do not pretend to be experts in patent matters, and have not the means at hand for readily lookingup such cases, but "Subscriber" can obtain the full specification of Mr. Levy's patent by sending twenty-five cents to the Commissioner of Patents at Washington. Our impression is that there are several patented processes in use for the same purpose, differing from each other in various details of material or manipulation. — EDS. AMERICAN ARCHITECT.]

FIRE-PROOF CEILINGS.

NEW YORK, January 16, 1883.

TO THE EDITORS OF THE AMERICAN ARCHITECT:—

Dear Sirs, — Although I am not now a regular subscriber to your very valuable paper I read the *American Architect* regularly, and with great interest.

Would you suggest me some material, fire-resisting if possible, to be put on ceilings. Something like linoleum, so that it could be nailed on the beams, and fastened with strips or otherwise. Plastering falls down sooner or later even if done with care.

Yours very respectfully, R. S.

[ASBESTOS felting answers a good purpose; it comes in long rolls about three feet wide, and can be tacked to the beams or furring strips. Where appearance is an object, the best way is to plaster the ceiling on wire-lath, which will hold the mortar so firmly that nothing can detach it. An inferior substitute for wire lathing, which costs less, and can be applied to old ceilings, is Power Bros.' patent wiring process, consisting in driving galvanized nails about six inches apart all over the ceiling, into the furrings or laths, and running diagonal lines of light brass wire across, giving it a turn around each nail, and crossing the ceiling in two directions. After the wires are applied the nails are driven close with a hammer, and a coat of hard-finish put over the whole. — EDS. AMERICAN ARCHITECT.]

THE "BRITISH ARCHITECT" AND MR. RICHARDSON.

ROCHESTER, N. Y., January, 24, 1883.

TO THE EDITORS OF THE AMERICAN ARCHITECT:—

Dear Sirs, — Do you see the *British Architect*, and if so, do you notice what some enterprising sketcher is doing in the way of sending pictures of recent American architecture credited to the wrong party. Of course the blunder will annoy the firm to which the work is erroneously attributed quite as much as the real architect. Doubtless Mr. Richardson will console himself with the reflection that the drawings do scant justice to the buildings, which certainly are among the best work which we have a right to consider American, but it does seem odd that the prevailing indifference to the identity of the architect, of even a successful building, should not have found an exception in the case of one who was able to make such a good choice of subjects for his sketching. Yours,

JAMES G. CUTLER.

[WE understand that the mistake to which our correspondent refers was made very innocently, and without fault of any one. A draughtsman in a Boston office wrote to the editors of the *British Architect*, asking if they would accept and publish sketches of certain buildings which he admired, mentioning at the same time the name of the architect. They returned a favorable reply, and in due time the sketches were received, but the author of them, thinking that his previous letter would prevent any possible mistake as to the name of the architect of the buildings, naturally omitted to mention the matter again, and the editors, just as naturally, having forgotten about the letter, and seeing no indication on the drawings of the architect's name, supplied the deficiency, although with a mark of interrogation, from the printed heading on the draughtsman's second letter, which accompanied the sketches. No doubt they will do all that can be done to remedy any annoyance which the error may have caused. As we have much the same opinion of Mr. Richardson's buildings at North Easton and Quincy as that which Mr. Cutler holds, it gives us pleasure to state that we shall shortly be able to publish gelatine prints of all of these buildings. — EDS. AMERICAN ARCHITECT.]

FURNISHING DETAIL-DRAWINGS FOR ESTIMATING.

ST. LOUIS, January 17, 1883.

TO THE EDITORS OF THE AMERICAN ARCHITECT:—

Dear Sirs, — A customer of mine complains at not having his detail-drawings furnished at the same time with the general drawings and specifications, claiming that he thereby lost several bids which might have been much to his advantage. This work was begun at the beginning of an extremely busy season, and with no stipulation as to the time when the details should be made.

I have replied that in the absence of any stipulation to the contrary it was understood that the work was to be done in the usual way, *i. e.*, to let the contract from the general drawings and to furnish the details as needed during the progress of the buildings.

This has always been my custom, and so far as I know is the custom of the majority of architects everywhere; and for several good reasons. Experienced mechanics can easily make out their bids from the general drawings, and do so every day. Until the bids are opened the exact cost cannot be determined, nor can the owner decide whether he will build precisely as planned, or make material changes, or decline to build at all. In the latter case details made before the letting become useless and an unnecessary expense to the owner; while if material changes are made the altering of such details may be even more expensive than making new ones entirely, without any compensating advantage.

I would be glad of an expression from the editors of the *American Architect* on the above points. It will be understood that marginal details were provided as usual in the specification and on the general drawings.

ARCHITECT.

["ARCHITECT" is certainly right in thinking that the custom of architects is to leave all detail-drawings except such as may be necessary to explain the work, or may be asked for by contractors while estimating, to be made as the work progresses. Generally, this saves trouble for all parties. To say nothing of the probability that modifications will be made in the design while being carried into execution, which would render detail-drawings previously made useless, it rarely happens that the work actually agrees exactly with the figures on the plans, and endless mistakes and misfits are avoided by making the detail-drawings for finish, not approximately from the plans, but from measurements of the places where the work is to go. In the particular case of which "Architect" speaks, we suspect that the owner has been talking with some disappointed contractor. It is possible that builders might refuse to estimate upon plans for ordinary buildings without full details, but such cases are rare, at least in this country, and our impatient owners would hardly endure the delay which such conduct would impose upon them.—EDS. AMERICAN ARCHITECT.]

THE $300-HOUSE COMPETITION.

TO THE EDITORS OF THE AMERICAN ARCHITECT:—

Dear Sirs, — I would like to offer a suggestion for the next competition to this effect, that when a builder gives an estimate on a design he be requested to allow his name to be published with it.

This would certainly prevent such a careless estimate as was made for "*Danfors*," as no "reliable builder" would let his name appear against that sum as a guaranty that he would complete the work for it. I know that it would be impossible to build in the vicinity of Boston according to the drawings and specifications, the charming house designed by "*Danfors*" and published in the *American Architect*, of the 20th inst., without a very much larger expenditure of money than he asks for. I would suggest, too, that the estimates be made to cover everything. The *Advertiser* calling attention to the article in the *American Architect*, saw only the added-up columns of figures; but in the specifications both the grading and furnaces are omitted items and important ones too, for which the owner must spend a few hundred dollars more.

It makes the competition an unfair one, putting the more experienced draughtsman to a decided disadvantage; for he, knowing better how much can be done for a fixed sum, would not attempt anything so ambitious. So it seems to me that the fault lies with the estimates, and I do not believe a builder would object to have his name appear with his estimates, since his capability for doing so much for so little would bring him in any quantity of work. C.

[We anticipated that the publication of the detailed estimates and prices submitted in this competition would call out a good many objectors, and when the adverse criticism is levelled at a designer working in another locality than the critic, we are prepared to disregard many things that may be said. In the present case, however, our correspondent *C.* and "*Danfors*" are fellow-townsmen who are building under similar conditions. As to the special points mentioned by *C.*, we will say, without prejudice to the jury's own conclusion on the subject, that grading-up with the excavated material should have been included in the estimate, but not any grading with fresh material. It was left optional with the competitors to include heating-apparatus, or to merely provide for its future introduction. As to questioning the reliability of the estimate because of its apparent inadequacy, *C* is too old a practitioner to be surprised at any instance of the astounding arithmetical feats that even the really "reliable" builder is capable of performing every day in the week. Figures submitted in competitive estimates are usually taken *cum grano salis*, and in the present competition as the "reliable builders" did not have before them the restraining possibility that their bids might be accepted it would be well for those who are tempted

by the published designs and figures to remember to double the dose. *C* will find that a number of competitors have forestalled his suggestion by furnishing as additional proof of their own *bona fides* the names of the builders who figured on their designs, and we hope that in all such cases the publication of the builder's name will conduce largely to his pecuniary benefit. In reply to our inquiry, "*Danfors*" informs us that though his builder does not care to have his name published he has again examined his computations and believes the work can be done for the sum named; at any rate he would be glad to make the attempt. We do not see that the advantage the inexperienced designer has over the more experienced is any greater in this competition than in any other.—Eds. American Architect.]

NOTES AND CLIPPINGS.

Fall of an English Church Tower.— On Friday evening, Dec. 2?), the tower of the parish church at Freckenham, in the east of England, fell. The tower was a square one, and contained five bells, which were rung as usual at Christmas time. It had been for some time past in a dilapidated state, and was patched up occasionally. Fortunately, the tower fell away from the church, or its fabric must have been damaged.

The Anarchists and the Tuileries.— The contractors who have undertaken to cart away the Palace of the Tuileries have received some curious proposals and suggestions. Mlle. Louise Michel offers in the name of "a group of anarchists" to remove free of charge "the remains of the former den of tyrants," and she undertakes that the work shall be finished "by the 14th of July, the anniversary of the taking of the Bastille by the noble populace."

The Originator of the Isthmus Ship-Railway Scheme.—In *La Nature* (Paris, December 16) appears a letter from Mons. A. Sebillot, an engineer, complaining that the credit of the details of the Tehuantepec Ship-Railway has been wrongly given to Captain Eads. He says that the proposed method of transport is fully described in a pamphlet which he published in Paris, 1879. He maintains that the project is a far more practicable one than that of the Panama Canal, and that it would be far less costly in money and time.

A new Style of Balloon.— An invention has been discovered in England in aeronautics which promises to revolutionize that somewhat erratic science. "A balloon had been constructed, the lower part of which consisted of very fine asbestos cloth, while the upper portion, which was of canvas, was covered with a fire-proof solution. The balloon was cylindrical in shape, and its cubic contents amounted to about 3,000 cubic feet. The neck of the balloon was provided with a copper spirit lamp, and upon igniting the latter the balloon was filled with astonishing rapidity. The balloon, though only a model, was very nearly as large as an ordinary one, and the rapidity which was attained in filling it is most certainly an advantage which cannot be overlooked. The difference in the cost between the gas required in the one instance and the spirit in the other is, moreover, an item of some importance, while the impossibility of carrying about sufficient gas, as compared with the facility for taking everywhere as much spirit as may be required for a large number of ascents, must strike the minds of those interested in this direction as very favorable."— *Exchange.*

How to Get Telegraph-Wires underground.— The proposition to tax overhead electrical conductors at twice the rate per mile charged for underground conductors is a discrimination in the right course, but only good so far as it goes. It might be improved so as to make the tax an incentive to a prompt removal of overhead wires from the streets. If the tax on underground wires should be made merely nominal for five or ten years, it would put no obstacle in the way of a costly enterprise that is necessarily attended with considerable risk to the investors. But, on the other hand, the tax on overhead wires should be made heavier year by year, until it becomes prohibitory. This is probably the simplest and most effective way of compelling the removal of overhead wires from the streets. If five dollars per mile is a sufficient tax now, it should be raised to ten in 1884, to twenty in 1885, and so on until there are no more overhead wires to tax. But fair warning should be given, so that the telegraph, telephone and electric-light companies may have an opportunity to avoid such taxation by putting their conductors underground.—*Philadelphia Ledger.*

The Burning of Stanford Court.— Stanford Court, one of the most beautiful places in England, has shared the fate of Ingestre and of Clevedon. The priceless manuscripts, one of the best private collections in the country, perished in the flames, and a most interesting series of family portraits of the Tudor period, painted on panels, were burnt; so also was a very fine gallery of old pictures, many of which were of great historical interest. Stanford was a charming old house, built by the Salweys in the reign of Queen Anne, to replace a Tudor manor-house. It stood on a wooded hill in a large park, and commanded grand views of the Teme valley. The house contained numerous secret passages and concealed rooms which were used by Romish priests and perverts in the good old days. It abounded in the most exquisite carved wainscoting. Not long ago a country house of Lord Hertford's, which had just been rebuilt, was burnt down, and £13,000 were lost, as the insurance had been accidentally postponed. Here it is the same thing. There was an old insurance on the house of £10,000, but nothing on the contents. Sir Francis Winnington had been for some time negotiating with an office, and on the very morning of the disaster the forms came down to effect a further insurance of £50,000.

The total damage and loss are estimated at £80,000. Sir Francis and Lady Winnington had gone on a few days' visit to Colonel Butler, at Snakenhurst, near Cleobury Mortimer. Sir Francis arrived at one o'clock, bitterly lamenting the destruction of his ancestral home. The old butler resolutely refused to quit the house, and it was necessary to use force to convey him to a place of safety. — *London Truth.*

Adhesive Power of Nails and Screws.— The extensive use to which nails and screws are put in construction lends considerable interest to any records of experience tending to discover their holding power. Haupt in his "Military Bridges" gives a table of the holding power of wrought-iron 10*d.* nails, 77 to the pound, and about 3 inches long. The nails were driven through a 1-inch board into a block and the board was then dragged in a direction perpendicular to the length of the nails. Taking a pine plank nailed to a pine block with eight nails to the square foot, the average breaking weight per nail was found to be 380 pounds. Similar experiments with oak showed the breaking weight to be 415 pounds. With 12 nails to the square foot the holding power was 542¼ pounds, and with six nails in pine 463¼ pounds. The highest result obtained was for 12 nails to the square foot in pine, the breaking weight being in this case 612 pounds per nail. The average strength decreases with the increase of surface. Tredgold gives the force in pounds required to extract 3*d.* brads from dried Christiana deal at right angles to the grain of the wood as 58 pounds. The force required to draw a wrought-iron 6*d.* nail was 187 pounds, the length forced into the wood being 1 inch. The relative adhesion when driven transversely and longitudinally is, in deal, about 2 to 1. To extract a common 6*d.* nail from a depth of 1 inch in dry beech, across grain, required 167 pounds; in dry Christiana deal, across grain, 187 pounds, and with grain 87 pounds. In elm the force required was 327 pounds across grain, and 257 with grain. In oak the figure given was 507 pounds across grain. From further experiments it would appear that the holding power of spike-nails in fir is from 460 to 730 pounds per inch in length, while the adhesive power of screws 2 inches long, 0.22 inch in diameter at the exterior of the threads, 12 to the inch, driven into a half-inch board, was 790 pounds in hard-wood and about one-half that amount in soft wood.— *The Iron Age.*

A Tunnel that refuses to remain a Tunnel.— In Castle District, at a point about five miles north of this city, is a tunnel that may be called an ex-tunnel. It is a tunnel that remonstrates against being a tunnel. It was run about four years ago into the side of a steep hill, and was originally about 40 feet in length. When in about 15 feet the tunnel cut into a soft, swelling clay, very difficult to manage. After timbering and striving against the queer, spongy material until it had been penetrated some 25 feet, the miners gave up the fight, as they found it a losing game. Being left to its own devices, the tunnel proceeded to repair damages. It very plainly showed that it resented the whole business, as its first move was to push out all the timbers and dump them down the hill. It did not stop at that, but projected from the mouth of the tunnel a pith or stopper of clay the full size of the excavation. This came out horizontally some eight feet, as though to look about and see what had become of the miners, when it broke off and rolled down the slope. In this way it has been going on until there are some hundreds of tons of clay at the foot of the hill. At first it required only about a week for a plug to come out and break off, then a month, and so on, till now the masses are ejected but three or four times per year, yet the motion continues, and to-day the tunnel has the better of the fight by about four feet.— *Virginia (Nev.) Enterprise.*

Improved Process of Etching Glass. — An appreciable extension of the means of artistically ornamenting glass surfaces has been made by Dr. W. Grüne, of Berlin. Using for the etching functions the familiar fluoric acid, he has initiated the employment of a resisting or partly resisting material in powder. The powdered materials allow the acid to flow between the particles, thus leaving a series of minute spots or holes between each particle, caused by the acid directly getting at the minute uncovered portions of the glass and acting less completely, or not at all, on the portions covered by the resist. The result is a dead or matted surface where the powder has been applied. The pattern may be bright and incised while the groundwork is dead and intaglio; or the pattern may be in intaglio and the groundwork bright and incised. A published description says: —

If the resisting substances are powdered when placed upon the surface of the glass with very finely divided metal copal, or other substances resisting the action of the acid for a longer time, and are allowed to dry on after breaking them with the acid, a more or less matted result is obtained. The corrosive action being very quickly performed, those parts of the pattern required to be bright need not be covered by any resists whatever. Only feebly resisting substances being required which would be useless for the ordinary method of procedure, all the well-known methods of drawing with a brush, pen, stylus, etc., can be employed. The inventor also takes advantage of thin and thick resists, using sometimes fine and coarse materials for powdering, obtaining thereby a matted appearance of different density or grain. In a drawing one can, therefore, obtain different and variegated shading by the simple use of various materials on one and the same surface.

The process is twofold: first the operation by which a matted patter or drawing is put upon the glass; secondly, the process by which a bright pattern may be reserved upon the glass, the groundwork being matted. For the process, the drawing is put upon the object either by hand, transfer, or direct printing, with almost any oil or varnish mixed with a little color to render it visible. It is then powdered by means of a brush or a tuft of cotton wool, or in other suitable manner, with pulverized metal copal or similar substances. What is known commercially as "bronze powder" is considered suitable for the purpose. After having dried, it is dipped into fluoric acid, or this may also be put on with a brush, if desirable. After a few seconds the powder begins to shale off. The glass is then washed in water. The greasy printing colour comes off in the course of the process. The second process is on this wise: Either paint, draw, or print the pattern in a material resisting fluoric acid, such materials being well known. When dry, oil over the whole surface by means of an ordinary printer's composition roller, with a greasy printing colour or oil varnish; then powder, treat with acid, and wash, as described in the first process. Remove the resist pattern either with an alkaline solution, benzine, alcohol, or like solvent. Instead of applying the acid as a bath or by a brush, it may be applied in the form of fine spray.—*The Artist.*